WAKE TECH COMMUNITY COLLEGE

TECHNOLOGY 4.0 BUILDING

12/20/2023

BID SET

VOLUME 2

LORD AECK SARGENT

WAKE TECH COMMUNITY COLLEGE

TECHNOLOGY 4.0 BUILDING

12/20/2023

BID SET

DESIGN TEAM:

Architecture
Lord Aeck Sargent

Civil Engineering
McAdams

Landscape Architecture
Surface678

Structural Engineering
Lynch Mykins

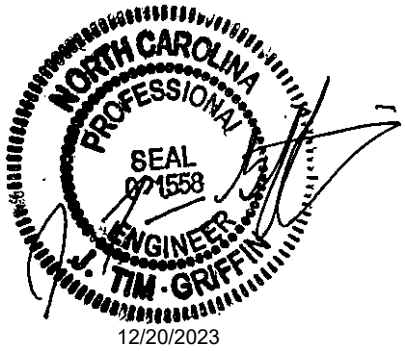
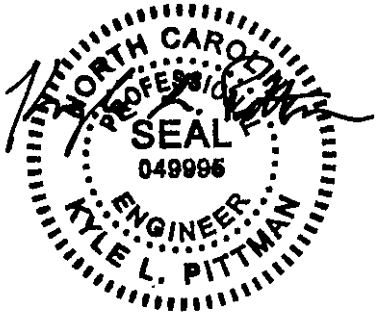
MEP / FP Engineering
RMF Engineering

RMF Engineering
Reliability. Efficiency. Integrity.

Audio / Visual Design
BrightTree Studios

Acoustics
Thorburn Associates

SECTION 00 01 07 - SEALS PAGE

ARCHITECTURAL  	**CIVIL** 
LANDSCAPE  	**STRUCTURAL** 
FIRE PROTECTION, PLUMBING, & MECHANICAL  	**ELECTRICAL, AUDIOVISUAL, SECURITY, & FIRE ALARM** 

END OF SECTION

SECTION 00 01 10 - TABLE OF CONTENTS

END OF SECTION

SECTION 21 05 17 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Grout.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.01 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.02 11STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Smith, Jay R. Mfg. Co.
   2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.03 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. CALPICO, Inc.
   3. Metraflex Company (The).
   4. Pipeline Seal and Insulator, Inc.
   5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.04 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.05 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 SLEEVE INSTALLATION

A. For all sleeves referenced below, install sleeves only for piping passing through the lower lever floor slab or as required by UL details on the plans.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Firestopping."

3.02 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
   3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.

4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Firestopping."

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.04 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
4. Interior Partitions:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION

SECTION 21 05 18 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated. 1

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

2.02 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
      c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
      d. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
      e. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with rough-brass finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.

3.02 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

SECTION 21 05 48 - VIBRATION CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Elastomeric isolation pads.
   2. Spring hangers.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For testing agency.

C. Welding certificates.

1.04 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Hanging, bracing, and restraint of fire sprinkler piping shall be in accordance with chapter 9.1 and 9.2 of NFPA 13.

PART 2 PRODUCTS

2.01 GENERAL

A. Select vibration isolating units for the lowest operating speed of equipment, so designed that natural frequency of equipment and base mass is not less than 1.5 times the lowest operating frequency of the moving equipment, but not a multiple or harmonic of the base frequency. Furnish vibration isolation producing a uniform loading and deflection even when equipment weight is not evenly distributed, vibration isolation shall be stable during starting and stopping of equipment without excessive traverse and eccentric movement of equipment.

B. The installed vibration isolation system for each floor or ceiling mounted item of equipment shall have a maximum lateral motion under equipment start up and shut down conditions of 1/4 inch. Motions in excess shall be restrained by approved spring type mounting.

C. The type of isolation, base, and minimum static deflection shall be as required for each specific equipment application, but not less than that specified herein when supported on a solid concrete structural slab having a thickness of not less than four (4) inches. Should vibration isolators installed for the equipment prove inadequate to prevent transmission of equipment vibrations to the building structure or limit equipment vibration originated noise in the building spaces to acceptable levels, the isolators shall be replaced with units having the largest deflection that can be practicably installed.

2.02 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation Co., Inc.
h. Vibration Mountings & Controls/Korfund.
i. Vibro-Acoustics, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.

2.03 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation Co., Inc.
h. Vibration Mountings & Controls/Korfund.
i. Vibro-Acoustics, Inc.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod (where required).
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.03 VIBRATION ISOLATION SCHEDULE

A. Fire Pump:
   1. Isolation Type: Elastomeric Isolation Pad
   2. Base Deflection: 0.4”
   3. Base Type: Integral to equipment.
   4. Remarks: Under skid.

B. Pressure-Maintenance Pump:
   1. Isolation Type: Elastomeric Isolation Pad
   2. Base Deflection: 0.4”
   3. Base Type: Integral to equipment.
   4. Remarks: Under skid.

C. First Four (4) Pipe Hangers near Isolated Equipment:
   1. Isolation Type: Spring Hanger
   2. Deflection:
      a. Piping 3-inches and smaller: 0.75”
      b. Piping 4-inches to 6-inches: 1.5”
      c. Piping Larger than 6-inches: 2.5”

END OF SECTION

SECTION 21 05 53 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

D. Valve Schedules: Valve numbering scheme.

1.03 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each piping system to include in maintenance manuals.

1.04 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. All major Fire Protection equipment, including is properly identified with equipment identification, equipment controlled, electrical ratings and date of installation.
2. For serviceable equipment such as valves, etc. located above an acoustical lay-in ceiling, provide a clear adhesive label on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the ceiling access panel for that piece of equipment. The label shall indicate the equipment designation in black text with minimum 3/8” high lettering.
3. For miscellaneous equipment requiring access such as valves, access doors, etc., provide a ¾” colored adhesive button on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the engineer) or on the access panel for that piece of equipment. Button colors shall be as follows; Fire Protection - Red.
4. Material and Thickness: Equipment should be clearly identified with engraved phenolic nameplates securely fastened to the equipment with sheet metal screws. Equipment name/numbers shall be the same as shown in the contract documents and the BAS Control drawings. Nameplates smaller than 4” by 2” shall only be allowed with approval from the designer.
5. Letter Color: Black
6. Background Color: White
7. Minimum Label Size: Shall be a minimum 4” by 2”.
8. Minimum Letter Size: ½” minimum.
9. Fasteners: Sheet metal screws.

10. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Identification shall be provided as follows: no further than 30 feet apart, at major changes in direction, at each valve or equipment, and on both sides of penetrations.

B. Pipe Labels: Provide stencil or strap-on identification indicating the system and the direction of flow.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Completely paint piping systems in mechanical rooms with applicable colors listed below.
2. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
3. Lettering Size: At least 1/2 inches high.

D. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.

E. For insulated and un-insulated pipe systems, stencil sizes are as follows:
1. For pipes up to 1 inch, use ½ inch letters, 8” wide color band.
2. For pipes >1 inch to 2 inches, use ¾ inch letters, 8” wide color band.
3. For pipes >2 inches to 4 inches, use 1 ¼ inch letters, 12” wide color band.
4. For pipes >4 inches to 6 inches, use 1 ¼ inch letter, 12” wide color band.
5. For pipes above 6 inches, use 4 inch letters, 24” wide color band.

2.04 VALVE TAGS

A. Valve Tags: Stamped or engraved.
1. Tag Material: Brass valve tags, minimum 1.5” diameter, minimum ¼: high lettering for the service matching the chart in paragraph b. above, minimum ½” high lettering indicating valve number, with brass or stainless steel chains for all isolation, branch and control valves.

2. Valve tag chart to be included in the O&M manual.
3. Valve tag chart to be mounted in all ME rooms in a frame with lexan cover.
4. Include the tag numbers in the as-built drawings and record drawings.
5. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inchbond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data and framed under a rigid plastic cover in each of the mechanical room and penthouse. Locate framed valve tag schedule adjacent to the door of the mechanical room and penthouse.

2.05 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
1. Size: 3 by 5-1/4 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of fire protection equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 30 feet along each run in concealed and un-concealed areas.
7. Controls conduit shall be specified as factory painted.
8. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
9. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.
10. For insulated and un-insulated pipe systems, stencil sizes are as follow:
a. For pipes up to 1 inch, use ½ inch letters, 8” wide color band.
b. For pipes >1 inch to 2 inches, use ¾ inch letters, 8” wide color band.
c. For pipes >2 inches to 4 inches, use 1 ¼ inch letters, 12: wide color band.
d. For pipes >4 inches to 6 inches, use 1 ¼ inch letters, 12” wide color band.
e. For pipes above 6 inches, use 4 inch letters, 24” wide color band.

3.04 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. 1-1/2 inches, round.
   2. Valve-Tag Color:
      a. Natural.
   3. Letter Color:
      a. Black.

3.05 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.06 CEILING-TAG INSTALLATION

A. For serviceable equipment and valves located above an acoustical lay-in ceiling, provide a clear adhesive label on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the ceiling access panel for that piece of equipment. The label shall indicate the equipment designation in black text with minimum 3/8” high lettering.

B. For miscellaneous equipment requiring access such as valves, control dampers, access doors, etc., provide a ¾” colored adhesive button on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the access panel for that piece of equipment. Button colors shall be as follows; Fire Protection: Red.

3.07 COLOR CODING

A. Where painting is required, the following schedule shall be utilized.

Pipe/Duct System	**Pipe/Duct Color**	**Stencil Identification**	**Label Color**	**Lettering Color**
Sprinkler	Safety Red	SPKR	Safety Red	White
Fire Line	Safety Red	FIRE	Safety Red	White

END OF SECTION

SECTION 21 10 00 - WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following fire-suppression piping inside the building:
   1. Manual wet-type, Class I standpipe systems.
   2. Automatic Wet-pipe sprinkler systems.
   3. Dry-pipe sprinkler systems.

B. The work performed shall be complete in every respect. Each system that has been installed or modified shall be complete in accordance with the applicable codes, standards, Owner's Insurance Underwriter requirements, Manufacturer's recommendations and Underwriters Laboratories, Inc. (UL) listings.

1.02 SYSTEM DESCRIPTIONS

A. Combined Standpipe and Sprinkler System: Fire-suppression system with both standpipe and sprinkler systems. Sprinkler system is supplied from standpipe system.

B. Manual Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Has small water supply to maintain water in standpipes. Piping is wet, but water must be pumped into standpipes to satisfy demand.

C. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

D. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

1.03 PERFORMANCE REQUIREMENTS

A. Standard Piping System Component Working Pressure: Listed for at least 175 psig.

B. Fire-suppression standpipe system design shall be approved by authorities having jurisdiction.
   1. Unless otherwise indicated, the following is maximum residual pressure at required flow at each hose-connection outlet:
      a. NPS 2-1/2 Hose Connections: 175 psig.

C. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction. Secure all required approvals and inspection from the state of North Carolina; Department of Administration – State Construction Office.
   1. Margin of Safety for Available Water Flow and Pressure: 10% flow, 10 psig for static and residual, including losses through water-service piping, valves, and backflow preventers.
   2. Sprinkler Occupancy Hazard Classifications:
      a. Building Service Areas: Ordinary Hazard, Group 1.
      b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
      c. General Storage Areas: Ordinary Hazard, Group 1.
      d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
      e. Office and Public Areas: Light Hazard.
      f. Classrooms and Conference Rooms: Light Hazard
      g. Laboratory Areas: Ordinary Hazard, Group 1
      h. Machine & Wood Shop, Fabrication Area: Ordinary Hazard, Group 2
   3. Minimum Density for Automatic-Sprinkler Piping Design:
      a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
      b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
      c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
   4. Maximum Protection Area per Sprinkler: Per UL listing.

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Piping materials, including sprinkler specialty fittings.
   2. Pipe hangers and supports.
   3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
   4. Air compressors, including electrical data.
   5. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
   6. Hose connections, including size, type, and finish.
   7. Roof hose connections.
   8. Alarm devices, including electrical data.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Fire-hydrant flow test report.

D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable.

E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

F. Welding certificates.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For standpipe and sprinkler specialties to include in emergency, operation, and maintenance manuals.

I. Shop Drawings:
   1. The Contractor shall submit one electronic copy shop drawings, catalog cuts, and hydraulic calculations to the Designer for approval prior to being submitted to any State Agencies. Shop drawings shall show light fixtures, ducts, mechanical equipment, structural elements, and all other items which may affect the layout of sprinklers and piping. Plans showing sprinkler work shall be not less than 1/8 inch per foot.
      a. The AutoCAD prepared shop drawings shall be consistent and compatible with AUTOCAD format being used for the overall project.
      b. Shop drawing shall show all of the information required by NFPA Standard 13 for working plans and shall include drawings showing the location of all equipment, controls, piping, valves, and drains.
      c. The shop drawings shall indicate all areas to be sprinklered and type of hazard, locations and sizes of water supply pipe, major drains and tests, alarm check valve and water motor gong, risers and other main piping and valves, and the location of fire department connections. Complete riser diagrams shall also be submitted. The drawings shall locate by dimension all fire protection piping and sprinkler heads.

1.05 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a licensed professional engineer.
b. Designer must be a minimum NICET Level III, registered in the State of North Carolina.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 14, "Installation of Standpipe, Private Hydrant, and Hose Systems."

D. During the installation and warranty period, the Contractor shall provide emergency repair service for the sprinkler system within four (4) hours of a request by the Owner for such service. This service shall be provided on a twenty-four (24) hour per day, seven (7) days per week basis. Warranty shall start based on final acceptance.

PART 2 PRODUCTS

2.01 STEEL PIPE AND FITTINGS

A. Threaded-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and seamless with factory- or field-formed threaded ends.
1. Cast-Iron Threaded Flanges: ASME B16.1.
2. Malleable-Iron Threaded Fittings: ASME B16.3.
3. Gray-Iron Threaded Fittings: ASME B16.4.
4. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
5. Steel Threaded Couplings: ASTM A 865 hot-dip galvanized-steel pipe where indicated.

B. Grooved-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed, square-cut- or roll-grooved ends.
1. Grooved-Joint Piping Systems:
a. Manufacturers:
1) Anvil International, Inc.
b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, rubber gasket listed for use with housing, and steel bolts and nuts.

C. Plain-End, Schedule 10 Steel Pipe: ASTM A 135 or ASTM A 795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10.

D. Grooved-End, Schedule 10 Steel Pipe: ASTM A 135 or ASTM A 795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10; with factory- or field-formed, roll-grooved ends.
1. Grooved-Joint Piping Systems:
a. Manufacturers:
1) Anvil International, Inc.
b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron

housing with keys matching steel-pipe and fitting grooves, rubber gasket listed for use with housing, and steel bolts and nuts.

2.02 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping.

B. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
   1. Manufacturers:
      a. Central Sprinkler Corp.
      b. Fire-End and Croker Corp.
      c. Viking Corp.
      d. Victaulic Co. of America.

C. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
   1. Manufacturers:
      a. Elkhart Brass Mfg. Co., Inc.
      b. Fire-End and Croker Corp.
      c. Potter-Roemer; Fire-Protection Div.

D. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.
   1. Manufacturers:
      a. AGF Manufacturing Co.
      b. Central Sprinkler Corp.
      c. G/J Innovations, Inc.
      d. Triple R Specialty of Ajax, Inc.

E. Flexible Sprinkler Hose Fittings:
   1. Manufacturer:
      a. Reliable Automatic Sprinkler Co., Inc.
   2. Standard: UL 2443 & FM 1637
   3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
   4. Material: 304 Stainless Steel.
   5. Pressure rating: 175-psig minimum.
   6. Size: Same as connected piping, for sprinkler.

2.03 LISTED FIRE-PROTECTION VALVES

A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating.

B. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
   1. Manufacturers:
      a. Central Sprinkler Corp.
      b. Clow Valve Co.
      c. Crane Co.; Crane Valve Group; Crane Valves.
      d. Globe Fire Sprinkler Corporation.
      e. Grinnell Fire Protection.
      f. Hammond Valve.
      g. Mueller Company.
      h. NIBCO.
      i. Potter-Roemer; Fire Protection Div.
      j. Reliable Automatic Sprinkler Co., Inc.
      k. Star Sprinkler Inc.
      l. Stockham.
      m. United Brass Works, Inc.

n. Watts Industries, Inc.; Water Products Div.

C. Gate Valves: UL 262, OS&Y type.
1. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.
a. Manufacturers:
1) Clow Valve Co.
2) Crane Co.; Crane Valve Group; Crane Valves.
3) Crane Co.; Crane Valve Group; Jenkins Valves.
4) Hammond Valve.
5) Milwaukee Valve Company.
6) Mueller Company.
7) NIBCO.
8) Red-White Valve Corp.
9) United Brass Works, Inc.

D. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
1. Indicator: Electrical, 115-V ac, prewired, 2-circuit, supervisory switch.
2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.
a. Manufacturers:
1) Milwaukee Valve Company.
2) NIBCO.
3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.
a. Manufacturers:
1) Central Sprinkler Corp.
2) Grinnell Fire Protection.
3) McWane, Inc.; Kennedy Valve Div.
4) Milwaukee Valve Company.
5) NIBCO.

2.04 UNLISTED GENERAL-DUTY VALVES

A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.

B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.

C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.

D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.05 SPECIALTY VALVES

A. Sprinkler System Control Valves: FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.
1. Manufacturers:
a. AFAC Inc.
b. Central Sprinkler Corp.
c. Firematic Sprinkler Devices, Inc.
d. Globe Fire Sprinkler Corporation.
e. Grinnell Fire Protection.
f. Reliable Automatic Sprinkler Co., Inc.
g. Star Sprinkler Inc.
h. Venus Fire Protection, Ltd.
i. Victaulic Co. of America.
j. Viking Corp.

2. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
   a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
   b. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

B. Automatic Drain Valves: UL 1726, NPS 3/4, ball-check device with threaded ends.
1. Manufacturers:
   a. AFAC Inc.
   b. Grinnell Fire Protection.

2.06 PREACTION VALVES:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Globe Fire Sprinkler Corporation
2. Reliable Automatic Sprinkler Co., Inc. (The)
3. Tyco Fire Products LP
4. Venus Fire Protection Ltd.
5. Victaulic Company
6. Viking Corporation

B. Standard: UL 260.

C. Design: Hydraulically operated, differential-pressure type.

D. Include trim sets for alarm-test bypass, drain, electrical water-flow alarm switch, pressure gauges, drip cup assembly piped without valves and separate from main drain line, and fill-line attachment with strainer.

E. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gauges; low-air-pressure warning switch; air relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.

F. Air-Pressure Maintenance Device:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Globe Fire Sprinkler Corporation
   b. Reliable Automatic Sprinkler Co., Inc. (The)
   c. Tyco Fire Products LP
   d. Venus Fire Protection Ltd.
   e. Victaulic Company
   f. Viking Corporation
2. Standard: UL 260.
3. Type: Automatic device to maintain minimum air pressure in piping.
4. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig outlet pressure.

G. Air Compressor:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Gast Manufacturing Inc
   b. General Air Products, Inc
   c. Viking Corporation
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Motor Horsepower: Fractional.

4. Power: 120-V ac, 60 Hz, single phase.
5. Provide with dryer.

2.07 SPRINKLERS

A. Sprinklers shall be FMG approved, with 175-psig minimum pressure rating.

B. Manufacturers:
1. Central Sprinkler Corp.
2. Firematic Sprinkler Devices, Inc.
3. Globe Fire Sprinkler Corporation.
4. Grinnell Fire Protection.
5. Reliable Automatic Sprinkler Co., Inc.
6. Star Sprinkler Inc.
7. Viking Corp.

C. Automatic Sprinklers: With heat-responsive element complying with the following:
1. UL 199, for nonresidential applications.
2. UL 1767, for early-suppression, fast-response applications.

D. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
1. Open Sprinklers: UL 199, without heat-responsive element.
a. Orifice: 1/2 inch, with discharge coefficient K minimum 5.6.
b. Orifice: 17/32 inch, with discharge coefficient K minimum 8.0.

E. Sprinkler types, features, and options as follows:
1. Concealed ceiling sprinklers, including cover plate.
2. Flush ceiling sprinklers, including escutcheon.
3. Pendent sprinklers.
4. Quick-response sprinklers.
5. Upright sprinklers.

F. Sprinkler Finishes: Chrome plated, bronze, and painted.

G. Special Coatings: Wax, lead, and corrosion-resistant paint.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

I. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.08 HOSE CONNECTIONS

A. Manufacturers:
1. Central Sprinkler Corp.
2. Elkhart Brass Mfg. Co., Inc.
3. Grinnell Fire Protection.
4. Guardian Fire Equipment Incorporated.
5. McWane, Inc.; Kennedy Valve Div.
6. Mueller Company.
7. Potter-Roemer; Fire-Protection Div.
8. United Brass Works, Inc.

B. Description: UL 668, brass or bronze, 300-psig minimum pressure rating, hose valve for connecting fire hose. Include gate pattern design; female NPS inlet and male hose outlet; and lugged cap, gasket, and chain. Include NPS 1-1/2 or NPS 2-1/2 as indicated, and hose valve threads according to NFPA 1963 and matching local fire department threads.
1. Valve Operation: Nonadjustable type.
2. Finish: Rough chrome-plated.

2.09 FIRE DEPARTMENT CONNECTIONS

A. Manufacturers:
   1. Central Sprinkler Corp.
   2. Elkhart Brass Mfg. Co., Inc.
   3. Guardian Fire Equipment Incorporated.
   4. Potter-Roemer; Fire-Protection Div.
   5. Reliable Automatic Sprinkler Co., Inc.
   6. United Brass Works, Inc.

B. Wall-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE."
   1. Type: Flush, with two inlets and square or rectangular escutcheon plate.
   2. Type: Exposed, projecting, with two inlets and round escutcheon plate.
   3. Finish: Rough chrome-plated.

C. Exposed, Freestanding-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body, brass inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, and bottom outlet with pipe threads. Include brass lugged caps, gaskets, and brass chains; brass lugged swivel connection and drop clapper for each hose-connection inlet; 18-inch- high, brass sleeve; and round, floor, brass escutcheon plate with marking "AUTO SPKR & STANDPIPE."
   1. Finish Including Sleeve: Rough chrome-plated.

2.10 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Electrically Operated Alarm: UL 464, with 10-inch- diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.
   1. Manufacturers:
      a. Potter Electric Signal Company.
      b. System Sensor.

C. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
   1. Manufacturers:
      a. ADT Security Services, Inc.
      b. Grinnell Fire Protection.
      c. ITT McDonnell & Miller.
      d. Potter Electric Signal Company.
      e. System Sensor.
      f. Viking Corp.
      g. Watts Industries, Inc.; Water Products Div.

D. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.
   1. Manufacturers:
      a. McWane, Inc.; Kennedy Valve Div.
      b. Potter Electric Signal Company.
      c. System Sensor.

2.11 PRESSURE GAGES

A. Manufacturers:

1. AGF Manufacturing Co.
2. AMETEK, Inc.; U.S. Gauge.
3. Brecco Corporation.
4. Dresser Equipment Group; Instrument Div.
5. Marsh Bellofram.
6. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of 0 to 250 psig minimum.
1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

PART 3 EXECUTION

3.01 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in Part 1 "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.02 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.03 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.04 PIPING APPLICATIONS, GENERAL

A. Do not use welded joints.

B. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

C. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast- or malleable-iron threaded fittings; and threaded joints.

D. Underground Service-Entrance Piping: Ductile-iron, mechanical-joint pipe and fittings and restrained joints.

3.05 STANDPIPE SYSTEM PIPING APPLICATIONS

A. Standard-Pressure, Wet-Type Standpipe System, 175-psig Maximum Working Pressure:
1. NPS 2-1/2 and Smaller: Threaded-end, black, standard-weight schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints. Use ball valves where applicable. Coordinate with Section 21 12 00.

B. NPS Greater than 2-1/2: Threaded-end, black, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
1. NPS 5 and NPS 6: Grooved-end, black, standard-weight schedule 10 steel pipe with square-cut-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints. Use gate valves where applicable. Coordinate with Section 21 12 00.

3.06 SPRINKLER SYSTEM PIPING APPLICATIONS

A. Standard-Pressure, Wet-Pipe Sprinkler System, 175-psig Maximum Working Pressure:
1. NPS 1-1/2 and Smaller: Threaded-end, black, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.

2. NPS 2: Threaded-end, black, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
3. NPS 2-1/2 to NPS 3-1/2: Threaded-end, black, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
4. NPS 2-1/2 to NPS 3-1/2: Grooved-end, black, standard-weight steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
5. NPS 2-1/2 to NPS 3-1/2: Grooved-end, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
6. NPS 4 to NPS 6: Threaded-end, black, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
7. NPS 4 to NPS 6: Grooved-end, black, standard-weight steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
8. NPS 4 to NPS 6: Grooved-end, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.07 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13.
      a. Shutoff Duty: Use ball, butterfly, or gate valves.
   2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13.
      a. Shutoff Duty: Use ball, butterfly, or gate valves.
      b. Throttling Duty: Use ball or globe valves.

3.08 JOINT CONSTRUCTION

A. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.

B. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
   1. Ductile-Iron Pipe: Radius-cut-groove ends of piping. Use grooved-end fittings and grooved-end-pipe couplings.
   2. Steel Pipe: Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
   3. Dry-Pipe Systems: Use fittings and gaskets listed for dry-pipe service.

3.09 SERVICE-ENTRANCE PIPING

A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building. Refer to Division 33 for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

D. NOTE: The sprinkler system riser must not be connected until the sprinkler contractor has verified that the underground piping has been tested, flushed, and certified per NFPA 24 by the responsible underground piping contractor.

3.10 WATER-SUPPLY CONNECTION

A. Refer to Division 22 Section "Domestic Water Piping" for interior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water distribution piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. NOTE: The sprinkler system riser must not be connected until the sprinkler contractor has verified that the underground piping has been tested, flushed, and certified per NFPA 24 by the responsible underground piping contractor.

3.11 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

C. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

D. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

E. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

F. Install sprinkler piping with drains for complete system drainage.

G. Install sprinkler zone control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

H. Install drain valves on standpipes.

I. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

J. Install alarm devices in piping systems.

K. Hangers and Supports: Comply with NFPA 13 for hanger materials.
   1. Install standpipe system piping according to NFPA 14.
   2. Install sprinkler system piping according to NFPA 13.

L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

M. Fill wet-standpipe system piping with water.

N. Fill wet-pipe sprinkler system piping with water.

3.12 VALVE INSTALLATION

A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.

D. Specialty Valves:
   1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.

3.13 SPRINKLER APPLICATIONS

A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
   1. Rooms without Ceilings: Upright sprinklers.

2. Rooms with Suspended Ceilings: Concealed sprinklers as indicated.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Sidewall, dry sprinklers.
5. Rooms with wood slat ceilings: Black finish.
6. Sprinkler Finishes:
   a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view.
   b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
   c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.

3.14 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels and tiles.

B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.

3.15 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes, unless otherwise indicated. Refer to plan sheet for location.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter and flow-restricting device, unless otherwise indicated.

3.16 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire department connections in vertical wall.

B. Install freestanding-type, fire department connections in level surface.
   1. Install protective pipe bollards on two sides of each fire department connection. Refer to Section "Site Furnishings" for pipe bollards.

C. Install ball drip valve at each check valve for fire department connection.

3.17 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Include backflow preventer between potable-water piping and fire-suppression piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.

F. Electrical Connections: Power wiring is specified in Division 26.

G. Connect alarm devices to fire alarm.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.18 PAINTING, LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14. Paint exposed fire protection piping red.

3.19 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Energize circuits to electrical equipment and devices.
   4. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   5. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
   6. Coordinate with fire alarm tests. Operate as required.
   7. Verify that equipment hose threads are same as local fire department equipment.

B. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.20 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

C. Protect sprinklers from damage until Final Acceptance.

3.21 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

END OF SECTION

SECTION 21 12 00 - FIRE-SUPPRESSION STANDPIPES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes entire standpipe system from fire department connection to fire hose connection.

1.02 SUBMITTALS

A. Shop Drawings: Indicate supports, components, accessories, and sizes.

B. Product Data: Submit manufacturer's catalog sheet for equipment indicating rough-in size, finish, and accessories.

C. Field Test Reports: Indicate compliance with specified performance.

D. Manufacturer's Installation Instructions: Submit with product data.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit servicing requirements and test schedule.

1.04 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 14, FM Global, and the Town of Wendell.

B. Maintain one copy of each document on site.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

B. Installer: Company specializing in performing Work of this section with minimum three years experience.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in shipping packaging until installation.

PART 2 PRODUCTS

2.01 FIRE HOSE CABINETS

A. Manufacturers:
   1. Crocker
   2. Potter Roemer
   3. Guardian

B. Furnish materials in accordance with Wake County and Wake Tech Construction standards.

C. Hose Cabinets:
   1. Style: Recessed mounted. Fire rated when installed in fire rated assemblies.
   2. Tub: 16 gage thick steel, prepared for pipe and accessory rough in.
   3. Door: 12 gage thick steel, flush, with 1/4 inch thick wired glass full panel, hinged, positive latch device, with self closing door.
   4. Finish: stainless steel.

2.02 VALVES

A. U. L. listed. FM Global, and approved with Wake County and Wake Tech.

B. Furnish materials in accordance with the Wake County and Wake Tech standards.

C. Hose Station Valve: Angle type, chrome plated finish, 1-1/2 inch nominal size, Class III.

D. Hose Connection Valve: Angle type; chrome plated finish; 2-1/2 inch size, thread to match Wake County approved fire department hardware, 300 psi working pressure, with threaded cap and chain of plastic caps.

E. Pressure reducing Valve: Angle type; chrome plated finish with inner hydraulic controls. 2-1/2 inch size, Wake County fire department thread, 400 psi inlet pressure, with threaded cap and chain of chrome plated finish.

F. Hose Connection Valve Cabinets:
   1. Style: Recessed mounted. Fire rated when installed in fire rated assemblies.
   2. Tub: 1 gage thick steel, prepared for pipe and accessory rough in.
   3. Door: 12 gage thick steel, flush, with 1/4 inch thick wired glass full panel, hinged, positive latch device, with self closing door.
   4. Finish: Stainless steel.

2.03 FIRE DEPARTMENT CONNECTION

A. Type: Flush mounted wall type with brass finish.

B. Outlets: Two-way with Wake County fire department thread size. Threaded dust cap and chain of matching material and finish.

C. Drain: 3/4 inch automatic drip, outside.

D. Label: "Standpipe - Fire Department Connection".

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify blocking in place for cabinet installation.

3.02 INSTALLATION

A. Install in accordance with NFPA 14 and FM Global.

B. Install Work in accordance with Wake County standards.

C. Install cabinets plumb and level. Secure to adjacent surfaces.

D. Install hose station valve in cabinet at 48 inches above floor. Install hose-connection valve under hose station valve and not closer than 4 inches from side or bottom of cabinet.

E. Connect standpipe system to water source ahead of domestic water connection.

F. Where static pressure exceeds 175 psi at any hose station, furnish pressure reducing valve to prevent pressure on hose exceeding 165 psi.

G. Provide fire hose valves at the highest landing in stairwells that exit to the roof.

H. Coordinate with section 21 10 00.

3.03 FIELD QUALITY CONTROL

A. Test entire system in accordance with NFPA 14.

B. Require test be witnessed by commissioning agent approved by Wake County and Wake Tech and Architect/Engineer.

3.04 CLEANING

A. Flush entire system of foreign matter.

3.05 PRESSURE GAUGE

A. Provide pressure gauge at the top of each accessibly riser,

END OF SECTION

SECTION 21 31 13 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Horizontally mounted, single-stage, split-case fire pumps.
   2. Fire-pump accessories and specialties.
   3. Flowmeter systems.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of fire pump, from manufacturer.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig minimum unless higher pressure rating is indicated.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.03 HORIZONTALLY MOUNTED, SINGLE-STAGE, SPLIT-CASE FIRE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. A-C Fire Pump; a Xylem brand
   2. Aurora Pumps; Pentair
   3. PACO Pumps; Grundfos Pumps Corporation, USA
   4. Patterson Pump Company; a Gorman-Rupp company
   5. Peerless Pump Company
   6. Pentair Pump Group

B. Pump:
   1. Standard: UL 448, for split-case pumps for fire service.
   2. Casing: Axially split case, cast iron, with ASME B16.1 pipe-flange connections.

3. Impeller: Double suction, cast bronze, statically and dynamically balanced, and keyed to shaft.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: Alloy steel shaft with bronze sleeve.
    a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
    b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.

C. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

D. Driver:
1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.
3. Capacities and Characteristics: Refer to drawings for capacities.

E. Capacities and Characteristics: Refer to drawings for capacities.

2.04 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.

B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.

C. Relief Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. BERMAD Control Valves
    b. CLA-VAL Automatic Control Valves
    c. Kunkle Valve
    d. OCV Control Valves
    e. WATTS
    f. Zurn Industries, LLC
2. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.

E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.

F. Discharge Cone: Closed type.

G. Hose Valve Manifold Assembly:
1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: UL 1726.
5. Manifold:
    a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
    b. Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
    c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ends threaded according to ASME B1.20.1.
    d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
    e. Escutcheon Plate: Brass or bronze; rectangular.
    f. Exposed Parts Finish: Polished.
    g. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

6. Voltage and Current Meters: Provide door mounted voltage and current meters so that the fire pump can be tested/inspected without opening the door.

2.05 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.06 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
   1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine equipment bases and anchorage provisions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of fire pumps.

B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:
   1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.
   2. Comply with requirements for vibration isolation devices specified in Section 21 05 48 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping.

F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings.

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.03 ALIGNMENT

A. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connections.

D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

3.04 CONNECTIONS

A. Comply with requirements for piping and valves specified in Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to drainage piping or point of discharge.

D. Connect flowmeter-system meters, sensors, and valves to tubing.

E. Connect fire pumps to their controllers.

3.05 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
   1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
   2. Test according to NFPA 20 for acceptance and performance testing.
   3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.07 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION

SECTION 21 39 33 - CONTROLLERS FOR FIRE-PUMP DRIVERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Full-service, reduced-voltage controllers rated 600 V and less.
   2. Controllers for pressure-maintenance pumps.

1.02 DEFINITIONS

A. ATS: Automatic transfer switch(es).

B. ECM: Electronic control module.

C. MCCB: Molded-case circuit breaker.

D. NO: Normally open.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of product indicated.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Show tabulations of the following:
      a. Each installed unit's type and details.
      b. Enclosure types and details for types other than NEMA 250, Type 2.
      c. Factory-installed devices.
      d. Nameplate legends.
      e. Short-circuit current (withstand) rating of integrated unit.
      f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
   4. Include diagrams for power, signal, alarm, control wiring, and pressure-sensing tubing.

1.04 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of product indicated, from manufacturer.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product indicated to include in emergency, operation, and maintenance manuals. Include the following:
   1. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
   2. Manufacturer's written instructions for testing, adjusting, and reprogramming any microprocessor-based logic controls.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.

B. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.

1.07 FIELD CONDITIONS

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. Environmental Limitations:

1. Ambient Temperature Rating: Not less than 40 deg F and not exceeding 122 deg F unless otherwise indicated.
2. Altitude Rating: Not exceeding 6600 feet unless otherwise indicated.

C. Interruption of Existing Electric Service: Notify Owner no fewer than ten days in advance of proposed interruption of electric service, and comply with NFPA 70E.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 20 and NFPA 70.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 FULL-SERVICE CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ASCO Power Technologies, LP; a business of Emerson Network Power
2. Eaton
3. Hubbell Incorporated
4. Joslyn Clark Corporation
5. Master Control Systems, Inc
6. Metron Control Products div. Hubbell Industrial Controls

B. General Requirements for Full-Service Controllers:
1. Comply with NFPA 20 and UL 218.
2. Combined automatic and nonautomatic operation.
3. Factory assembled, wired, and tested; continuous-duty rated.

C. Method of Starting:
1. Pressure-switch actuated.
   a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
   b. System pressure recorder, electric ac driven, with spring backup.
   c. Programmable minimum-run-time relay to prevent short cycling.
   d. Programmable timer for weekly tests.
2. Magnetic Controller**:** Wye-delta (closed transition) type.
3. Solid-State Controller: Reduced-voltage type.
4. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.

D. Method of Stopping: Nonautomatic.

E. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location. Minimum of 42KAIC.

F. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.

G. Door-Mounted Operator Interface and Controls:
1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:
   a. Microprocessor-based logic controller, with multiline digital readout.
   b. Membrane keypad.
   c. LED alarm and status indicating lights.
3. Local Alarm and Status Indications:

a. Controller power on.
b. Motor running condition.
c. Loss-of-line power.
d. Line-power phase reversal.
e. Line-power single-phase condition.
4. Audible alarm, with silence push button.
5. Nonautomatic START and STOP push buttons or switches.

H. ATS:
1. Complies with NFPA 20, UL 218, and UL 1008.
2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
4. Allows manual transfer from one source to the other.
5. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
6. Local Alarm and Status Indications:
a. Normal source available.
b. Alternate source available.
c. In normal position.
d. In alternate position.
e. Isolating means open.
7. Audible alarm, with silence push button.
8. Nonautomatic (manual, nonelectric) means of transfer.
9. Engine test push button.
10. Start generator output contacts.
11. Timer for weekly generator tests.

I. A loss of control signal integrity shall cause 1the fire pump generator to start up. Provide monitoring of the control conductors between the generator and the transfer switch.

2.03 ENCLOSURES

A. Fire-Pump Controllers and ATS: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.
1. Indoor, Dry and Clean Locations: Type 1 (IEC IP10).

B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".

C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.

D. Optional Features:
1. Floor stands, 12 inches high, for floor-mounted controllers.

2.04 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.
1. Verification of Performance: Rate controllers according to operation of functions and features specified.

B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.

B. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONTROLLER INSTALLATION

A. Coordinate installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Install controllers within sight of their respective drivers.

D. Connect controllers to their dedicated pressure-sensing lines.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Comply with NEMA ICS 15.

3.03 POWER WIRING INSTALLATION

A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.04 IDENTIFICATION

A. Comply with requirements in NFPA 20 for marking fire-pump controllers.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20.

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:
   1. Inspect and Test Each Component:
      a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
      b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
      c. Test continuity of each circuit.
   2. Verify and Test Each Electric-Drive Controller:
      a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Architect before starting the motor(s).
      b. Test each motor for proper phase rotation.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Field Acceptance Tests:
   1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Architect and authorities having jurisdiction.

2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
3. Engage manufacturer's factory-authorized service representative to be present during the testing.
4. Perform field acceptance tests as outlined in NFPA 20.

D. Controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

3.07 ADJUSTING

A. Adjust controllers to function smoothly and as recommended by manufacturer.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.

C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

D. Set field-adjustable pressure switches.

3.08 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Final Acceptance.

3.09 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controllers, and to use and reprogram microprocessor-based controls within this equipment.

END OF SECTION

SECTION 22 01 00 - COMMON WORK RESULTS FOR PLUMBING

PART 1 GENERAL

1.01 SUMMARY

A. This Section describes the common work requirements for the mechanical work included in Division 22 and applies to all sections of Division 22.

1.02 SUSTAINABLE DESIGN REQUIREMENTS – GREEN GLOBES

A. The Owner is pursuing Green Building Initiative (GBI) Green Globes for New Construction (NC) Certification.

B. Submit documentation to GBI-authorized Assessor and respond to questions and requests from GBI-authorized Assessor about Green Globes credits that are the responsibility of Contractor, that depend on product selection or product qualities, or that depend on Contractor's procedures until GBI-authorized Assessor has made its determination on Project's Green Globes certification application.

C. Document correspondence with GBI-authorized Assessor as informational submittals.

D. Refer to Division 1 sustainable design requirements for additional information.

1.03 COMMISSIONING

A. The Owner is pursuing Green Building Initiative (GBI) Green Globes for New Construction (NC) Certification. The scope of the commissioning effort is that which is required to facilitate fulfilling Fundamental Commissioning of the Building Energy Systems and Enhanced Commissioning.

B. All building energy-related systems shall be commissioned in order to verify and ensure that fundamental building elements and systems are installed, constructed, calibrated to operate, and perform according to the Owner’s Project Requirements, Basis of Design, and Construction Documents.

C. Refer to Divisions 1 and 22 commissioning specifications for additional information.

1.04 DEFINITIONS

A. Following are definitions of terms and expressions used in the Mechanical and Electrical Sections:

1. Provide: Furnish and install
2. Directed: Directed by the Architect or Engineer
3. Indicated: Indicated in Contract Documents
4. Concealed: Hidden from normal sight; includes items within furred spaces, pipe and duct shafts, above suspended ceilings and within return air plenums.
5. Exposed: Non-concealed - Work within Equipment Rooms shall be considered exposed.
6. Exterior: Items being or situated outside. Items located within a crawl space shall be considered exterior.
7. Conditioned: Heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means, so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.
8. Piping: Includes pipes, fittings, valves, hangers, and accessories comprising a system.
9. Ductwork: Includes ducts, fittings, housings, dampers, hangers, air devices, and accessories comprising a system.
10. Architect: Principal design professional for the project. In certain types of projects, the principal design professional may be an engineer rather than an architect. For such projects, within the bounds of these specifications, where the term “architect” is used, it may refer instead to the engineer.

1.05 CODES, REGULATIONS, AND PERMITS:

A. References to codes, standards, specifications, and regulations apply to the latest edition adopted by the jurisdiction where the project is located.

B. Give all necessary notices, obtain all permits, and pay all fees and other costs, including those for utility connections or extensions in connection with the work. File all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments having jurisdiction. Obtain all required certificates of inspection and deliver same to the Architect before request for acceptance and final payment for the work.

1.06 EQUIPMENT LIST

A. Provide a spreadsheet list of all equipment provided with the drawing tag number or designation, name, manufacturer, model number, serial number and full electrical characteristics.

B. This list shall be provided to the TAB agent, Commissioning Agent, BAS providers and to the Owner prior to beginning TAB work and as soon after all equipment is received on site.

1.07 EQUIPMENT START-UP AND INITIAL OPERATION

A. No equipment shall be operated, for testing or trial use, before full compliance with the equipment manufacturers' specifications and instructions for the lubrication, alignment, direction of rotation, balance, and other applicable considerations.

B. Particular care shall be taken to see that all equipment is completely assembled, properly lubricated, and all grease and oil cases and reservoirs have been filled to the correct level with the recommended lubricants.

C. It is the Contractor's responsibility to place each item of equipment, installed by him, in operating condition. This responsibility includes all auxiliaries, piping, wiring, etc., the start up of each unit, and a check of its performance.

1.08 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Refer to Section 017900 "Demonstration and Training" for additional information.

B. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment.

C. Contractor shall instruct the Owner's representative fully in the operation, adjustment, and maintenance of all equipment furnished.

1.09 DRAWINGS

A. The Contract Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Any offsets, rises, or transitions not shown on the drawings and required to provide a complete system shall be provided at no additional contract cost. Do not scale the drawings. Consult the Architectural and Structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

B. In the event of ambiguities within or between parts of the Contract Documents, the contractor shall 1) provide the better quality or greater quantity of work, or 2) comply with the more stringent requirement, either or both in accordance with the Architect's interpretation.

1.10 SINGULAR NUMBER

A. Where any device or part of equipment is herein referred to in the singular number (such as "valve"), such reference applies to as many such devices as are required to complete the installation as shown on the drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe and fittings shall be from a United States domestic manufacturer.

2.02 FIRE-RATED PENETRATIONS

A. Provide UL Listed fire penetration systems in openings in rated floors, walls, and other elements of construction. Provide UL listed fire penetration systems at all new and existing pipe penetrations of new and existing rated construction within the area of work. Coordinate work of this section with all other trades necessary for the proper installation of the fire rated penetration systems.

B. Submit shop drawings showing each condition requiring penetration seals in dictating proposed UL systems materials, anchorage, methods of installation, and actual adjacent construction. Submit a copy of UL illustration of each proposed system indicating manufacturer approved modifications. Submit copies of manufacturer's specifications, recommendations, inspection requirements, installation instructions, and maintenance data for each type of material required. Include letter indicating that each material complies with the requirements and is recommended for the applications shown.

C. All fire penetration systems shall reference ASTM E814/UL 1479 - Fire Test of Through - Penetration Fire Stops.

D. All systems shall be UL tested and listed in the UL Fire Resistance Directory.

E. Submit copies of written guarantee agreeing to repair or replace joint sealers which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be one (1) year from date of substantial completion.

F. 3M products have been specified as the penetration fire stop basis of design. Other manufacturer's systems are acceptable providing they meet the requirements set forth in this specification. The fire rated penetration systems shall be the products of one manufacturer to the maximum extent possible. The products of more than one manufacturer shall not be used as a combined seal.

G. Provide materials classified by UL to provide fire stopping equal to time rating, both "F" and "T" ratings, of construction being penetrated. Provide asbestos free materials that comply with applicable codes and have been tested under positive pressure in accordance with UL 1479 or ASTM E814. Systems shall be smoke and air tight.

H. Deliver material undamaged in manufacturer's clearly labeled, unopened containers identified with brand, type, grade, and UL label where applicable. Coordinate delivery with scheduled installation date to allow minimum storage time at site. Store material in clean, dry ventilated location. Protect from soiling, abuse, and moisture. Follow manufacturer's instruction.

I. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

J. Furnish adequate ventilation if using solvent. Furnish forced air ventilation during installation if required by manufacturer. Keep flammable materials away from sparks or flame. Provide masking and drop cloths to prevent contamination of adjacent surfaces by fire stopping resistance.

K. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose, materials, rust, or other substances that may affect proper fitting, adhesion of the required fire resistance.

L. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instructions. Seal holes or voids made by penetrations to ensure an effective smoke barrier. Where floor openings without penetrating items are more than four (4) inches in width and subject to traffic or loading, install fire stopping materials capable of supporting same loading as floor. Protect materials from damages on surfaces subject to traffic.

M. Clean up spills of liquid components. Neatly cut and trim materials as required. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.

N. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities. Perform under this section patching and repairing of fire stopping caused by cutting or penetration by local inspectors and other trades.

PART 3 EXECUTION

3.01 WORKMANSHIP

A. The quality of workmanship required, for each trade, in the execution of work shall be the finest and highest obtainable in that trade working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality is final.

B. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.02 EQUIPMENT PERFORMANCE

A. All equipment, devices, controls, and hardware shall be proven to operate successfully throughout the guarantee period. Systems shall be proven during all-weather seasons and be demonstrated to affect the design conditions at times. System components or equipment items that fail to consistently deliver the design conditions shall be removed and replaced as directed by the Architect. The cost of required equipment replacements shall be borne by the Contractor.

B. All equipment shall be tested after installation and be proven to deliver the manufacturers quoted design capacity. When capacity is in question as deemed by the Architect, the Contractor shall perform a detailed and comprehensive field performance test to certify the equipment capacity. System effect or installed performance factors may not be applied to performance ratings unless they were previously included when the equipment was submitted for approval. Equipment that fails to deliver manufacturers quoted design capacity shall be removed and replaced at the Contractors expense.

C. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.03 EQUIPMENT CONNECTIONS

A. All equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, piping specialties, water seals, valves, and electric connections recommended by the manufacturer, required by code or required for proper operation shall be provided.

3.04 CUTTING AND PATCHING

A. Cutting and patching associated with the work shall be performed in a neat and workmanlike manner. Existing surfaces, which are damaged by the Contractor, shall be repaired or provided with new materials. All patching shall be done with materials and methods similar to existing adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary, non-percussive methods.

B. Patching of areas disturbed by installation of new work shall match existing adjacent surfaces in material, texture, and color.

3.05 PROTECTION OF EXISTING WORK

A. When working in and around the building, extreme care shall be exercised with regard to protection of the structure and mechanical services. Repair or replace, to the satisfaction of the Architect, any existing work damaged in the performance of the new work.

3.06 SURVEYS AND MEASUREMENTS

A. Base all measurements (both horizontal and vertical) from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check correctness of same as related to the work. Verify locations of existing utilities and inverts of same prior to the start of any systems shown connecting to existing utilities.

B. Should the Contractor discover any discrepancy between actual measurements or conditions, and those indicated, which prevent following good practice or the intent of the drawings and specifications, he shall notify the Architect and shall not proceed with his work until he has received instruction from the Architect.

3.07 HANDLING AND STORAGE OF MATERIAL

A. Proper and suitable tools, equipment and appliances for the safe and convenient handling and placing of all materials and equipment shall be used. During loading, unloading, and placing, care shall be taken in handling the equipment and materials so that no equipment or materials are damaged.

B. All equipment delivered to the job site shall be stored on pedestals, above the ground and under roof or other approved covering. All enclosures for equipment shall be weatherproof. All motors, drives, switchgear, panels, etc. which are not totally enclosed, that are involved in the work, shall be stored in a heated, dry, water protected area with a minimum temperature of fifty degrees (50) Fahrenheit. All valves shall be stored under roof on wood pedestals, above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.

C. If any equipment and/or materials are found to be in poor condition at the time of installation the Architect may, at his discretion, order the Contractor to furnish and install new equipment and/or material at no cost to the Owner.

3.08 COOPERATION WITH OTHER TRADES

A. Mechanical trades shall give full cooperation to other trades and shall furnish in writing, with copies to Architect any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. Exact location of all mechanical and equipment, devices, etc. in finished spaces shall be coordinated with Architectural reflected ceiling plans, elevations and details.

3.09 CLEANING AND PAINTING

A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition.

B. Restore and touch-up factory finishes which have been damaged during construction.

C. For areas of exposed rust, treat with water-based emulsion chemical rust converter. Brush, roll, or spray on the surface to be treated and allow to cure prior to paint/surface touch-up. Basis of design is Ultra Last CuRUST Chemical Rust Converter.

D. Cleaning Solutions: Cleaning solutions used to clean and flush piping systems or equipment shall not be discharged to the storm sewer system.

3.10 ACCESSIBILITY

A. Equipment shall be installed per manufacturer’s recommended clearance guidelines with sufficient space for maintenance personnel service, operate, and maintain equipment.

B. Maintenance Accessibility Plumbing Equipment:
   1. Clearances around equipment located above or below ceilings shall be sufficient to allow inspection, service, repair or replacement without removing elements of permanent construction and in accordance with the manufacturers recommended clearances.
   2. The contractor shall coordinate with all other trades to protect the service area around equipment.

C. Access Panels:
   1. All plumbing equipment, valves, etc. needing servicing, occasional access, etc. should be located above accessible lay-in ceilings as much as practical.
   2. If it is necessary to mount equipment above any drywall ceilings, or concealed within walls, provide suitable access panels appropriately sized and located to maintain the equipment.

D. Maintenance Clearances:
   1. Contractor shall provide the manufacturer's recommended clear maintenance access for all pieces of major equipment including.
   2. Provide a means and a pathway for replacing all equipment without major demolition including removing permanent elements of construction.

E. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner.

3.11 EXCAVATION AND BACKFILL

A. Refer to Section 312000 "Earth Moving" for additional requirements.

B. Definitions
   1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
      a. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
      b. Final Backfill: Backfill placed over initial backfill to fill a trench.
   2. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
   3. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   4. Fill: Soil materials used to raise existing grades.
   5. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
   6. Utilities: On-site underground pipes, as well as underground services within buildings.

C. Soil Materials
   1. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter
   2. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.
      a. Unsatisfactory soils include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
   3. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
   4. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
   5. Sand: ASTM C 33/C 33M; fine aggregate.

D. Excavation for Utility Trenches

1. Excavate trenches to indicated gradients, lines, depths, and elevations.
    a. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
2. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe unless otherwise indicated.
    a. Clearance: 12 inches each side of pipe.
3. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes on solid, undisturbed earth for the full length of each pipe, except for that portion at the bell holes. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes. Remove projecting stones and sharp objects along trench subgrade.
    a. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
    b. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
    c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
    d. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
4. Any part of the trench bottom excavated below the specified subgrade shall be backfilled, at the Contractor's expense, with bedding course materials.
    a. For utility trenches, compact bedding course soil material at 95 percent.
5. Whenever wet, or otherwise unstable, subgrade is encountered below the elevation of the original ground surface which existed prior to the time of construction, such soil shall be removed to the depth and extent direct by the Architect and the trench backfilled to the proper grade with bedding material as hereinafter specified. Reimbursement for extra work performed by the Contractor shall be in accordance with the General Conditions.
6. Provide shoring and sheet piling necessary for excavation and for the safety of personnel and property as directed. Unless otherwise directed, the sides of all excavations over four (4) feet deep must be braced. All shoring, bracing, sheet piling, etc., must be solidly installed heavy timber suitable for the purpose. No lumber shall be buried when excavations are backfilled, except by authority of the Architect.

E. Subgrade Inspection
1. Notify Architect when excavations have reached required subgrade.
2. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
3. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

F. Utility Trench Backfill
1. No backfill and/or bedding shall be placed until the construction adjacent thereto or the utility to be backfilled has been inspected, tested and approved. Notify the Architect when inspections are required.
2. Place backfill and beddings on subgrades free of mud, frost, snow, or ice.
3. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes.
4. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03.
5. Trenches under Roadways: Provide 4-inch- thick, concrete-base slab support for piping less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03.
6. Backfill voids with satisfactory soil while removing shoring and bracing.

7. Initial Backfill:
   a. Soil Backfill: Place and compact initial backfill of subbase material or satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe.
      1) Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping to avoid damage or displacement of piping.
      2) Backfill for plastic pipe shall be clean sand, free of foreign materials.
      3) Coordinate backfilling with utilities testing.
8. Final Backfill:
   a. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
9. Whenever the Architect requires the removal of wet or otherwise unstable subgrade from the fill material previously placed by the Contractor, the cost of all removal of unstable soil, together with backfilling of the trench as herein specified shall be borne by the Contractor.
10. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

G. Compaction of Soil Backfills and Fills
1. Following inspection as specified above, approved backfill material shall be deposited in the trench with hand shovels, not by means of wheelbarrows, carts, trucks, bulldozers, or similar equipment.
2. Place backfill and fill soil materials in layers not more than 4 inches in loose depth for material compacted by hand-operated tampers until the pipe has a cover of not less than two (2) feet. The remainder of the backfill material shall then be deposited in the trench in eight (8) inch layers and compacted.
3. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
4. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698 and ASTM D 1557:
   a. For utility trenches, compact each layer of initial and final backfill soil material at 95 percent of dry weight compaction.
5. Mechanical tampers, for compacting backfill, shall be tampers capable of exerting a blow equal to 250 foot-pounds per square foot (FT2) of area of the tamping face.
6. Work broken or ruptured by improperly placed backfill shall be removed and replaced by the Contractor at no additional cost to the Owner.
7. Any trenches improperly backfilled shall be reopened, then refilled and compacted to the required grade and smoothed off.

H. Field Quality Control
1. Test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
   a. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 100 feet or less of trench length but no fewer than two tests.
2. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.12 EQUIPMENT BASES AND SUPPORTS

A. Concrete bases, curbs, and supports will be furnished and installed under this Division and shall be in accordance with Division 3.

B. The Subcontractors shall furnish, to the General Contractor, all required foundation sizes, bolts, washers, sleeves, plates and templates for equipment.

C. The size of the foundation bolts shall be as recommended by the manufacturer.

D. All equipment shall be set on the foundations, shimmed level with steel shims, and grouted up under base for uniform bearing by the Subcontractor.

E. Under this Section, provide all equipment supports; consisting of inertia pads, platforms, gratings, structural members and related materials required for the mechanical and electrical work.

F. The type and size of the supporting channels and supplementary steel shall be determined by the Subcontractor and shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.

3.13 ATTIC STOCK:

A. All plumbing related attic stock shall be stored in an alternate location from the building or area under construction and turned over to the OWNER at the completion of the project, along with attic stock from the other trades packages.

END OF SECTION

SECTION 22 05 17 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.01 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide comparable product by one of the following:
1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.02 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide comparable product by one of the following:
1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with setscrews.

2.03 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide comparable product by one of the following:
1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.

3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.04 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide comparable product by one of the following:
   1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.05 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 SLEEVE INSTALLATION

A. For all sleeves referenced below, install sleeves only for piping passing through the lower lever floor slab, insulated pipe, or as required by UL details on the plans.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Firestopping."

3.02 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Firestopping."

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.04 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inchannular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system material.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inchannular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

END OF SECTION

SECTION 22 05 18 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

2.02 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

3.02 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

SECTION 22 05 19 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Thermometers
   2. Gages.
   3. Test plugs.

1.02 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.03 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Two gauges for each set of gauges with differing ranges.
   2. Two thermometers for each set of thermometers with differing ranges.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

PART 2 PRODUCTS

2.01 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Palmer - Wahl Instruments Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

2.02 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AMETEK, Inc.; U.S. Gauge Div.
   2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   3. Marsh Bellofram.
   4. Palmer - Wahl Instruments Inc.
   5. Trerice, H. O. Co.
   6. Weiss Instruments, Inc.
   7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   8. WIKA Instrument Corporation.
   9. Winters Instruments.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
   1. Case: Dry or Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.

3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass.
8. Ring: Metal or plastic.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

2.03 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc..
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

PART 3 EXECUTION

3.01 THERMOMETER APPLICATIONS

A. Install light-powered digital thermometers in the outlet of each domestic, hot-water heater

B. Install pressure gauges at the inlet and discharge of all pumps and pressure reducing valves.

C. Install light-powered digital thermometers at suction and discharge of each pump.

D. Provide the following temperature ranges for thermometers:
1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

3.02 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install dry-case-type pressure gages at suction and discharge of each pump.

C. Install pressure gauges at the inlet and discharge of all pumps and pressure reducing valves.

3.03 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install remote-mounting pressure gages on panel.

E. Install needle-valve and snubber fitting in piping for each pressure gage.

F. Install test plugs in tees in piping.

G. Install permanent indicators on walls or brackets in accessible and readable positions.

H. Install connection fittings for attachment to portable indicators in accessible locations.

I. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

J. Adjust faces of thermometers and gages to proper angle for best visibility.

K. On steam systems, provide siphon between gage and cock.

END OF SECTION

SECTION 22 05 23 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Bronze ball valves.
2. Iron butterfly valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Chainwheels.

B. Related Sections:
1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.02 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

1.03 SUBMITTALS

A. Product Data: For each type of valve indicated.

1.04 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from a single source from a single manufacturer.

B. ASME Compliance:
1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set ball open to minimize exposure of functional surfaces.
4. Set butterfly valves closed or slightly open.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles and drawings for applications of valves in Part 3.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6and smaller.
   4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inchstem extensions and the following features:
   1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   2. Butterfly Valves: With extended neck.

F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Grooved: With grooves according to AWWA C606.
   3. Solder Joint: With sockets according to ASME B16.18.
   4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.; Apollo Valves.
      b. Crane Co.; Crane Valve Group; Crane Valves.
      c. Jamesburg.
      d. Milwaukee Valve Company.
      e. NIBCO INC.
      f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig
      c. CWP Rating: 600 psig.
      d. Body Design: Two piece.
      e. Body Material: Bronze.
      f. Ends: Threaded.
      g. Seats: TFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Full.

B. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.; Apollo Valves.
      b. Jamesburg.
      c. Milwaukee Valve Company.
      d. NIBCO INC.

e. Watts Regulator Co.

2. Description:
   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Three piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.03 IRON, BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. DeZurik Water Controls.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Norriseal; a Dover Corporation company.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

2.04 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: Bronze.

B. Class 150, Bronze Swing Check Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Crane Co.; Crane Valve Group; Crane Valves.
      c. Crane Co.; Crane Valve Group; Jenkins Valves.
      d. Crane Co.; Crane Valve Group; Stockham Division.
      e. Milwaukee Valve Company.
      f. NIBCO INC.
   2. Description:
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 300 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

2.05 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Division.
      d. Kitz Corporation.
      e. Milwaukee Valve Company.
      f. NIBCO INC.
      g. Powell Valves.
      h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.

B. Class 250, Iron Swing Check Valves with Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Division.
      d. Hammond Valve.
      e. Milwaukee Valve Company.
      f. NIBCO INC.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 500 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.

g. Gasket: Asbestos free.

2.06 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Sprocket Rim with Chain Guides: Ductile or cast iron of type and size required for valve.
   3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully close. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for ball, butterfly, NPS 6 and larger and more than 72 inches above floor. Extend chains to 72 inches above finished floor.

F. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm’s length.

G. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

3.03 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated on drawings, use the following:
   1. Shutoff Service: Ball, butterfly
   2. Butterfly Valve Dead-End Service.
   3. Throttling Service: ball, or butterfly valves.
   4. Pump-Discharge Check Valves:
      a. NPS 2and Smaller: Bronze swing check valves.
      b. NPS 2-1/2and Larger for Domestic Water: Iron swing check valves
      c. NPS 2-1/2and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5and Larger: Flanged ends.
   4. For Steel Piping, NPS 2and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   6. For Steel Piping, NPS 5and Larger: Flanged ends.

3.05 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: full port bronze.
   3. Bronze Swing Check Valves:

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron, Butterfly Valves
   3. Iron Swing Check Valves

END OF SECTION

SECTION 22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Pipe positioning systems.
   8. Equipment supports.

1.02 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.03 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Fiberglass pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Powder-actuated fastener systems.
   5. Pipe positioning systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for weights associated for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Fiberglass strut systems. Include Product Data for components.
   4. Pipe stands. Include Product Data for components.
   5. Equipment supports.

C. Welding certificates.

1.05 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.2, "Structural Welding Code--Aluminum."
   3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 PRODUCTS

2.01 MANUFACTURERS

2.02 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers:
   1. AAA Technology & Specialties Co., Inc.
   2. Bergen-Power Pipe Supports.
   3. B-Line Systems, Inc.; a division of Cooper Industries.
   4. Carpenter & Paterson, Inc.
   5. Empire Industries, Inc.
   6. ERICO/Michigan Hanger Co.
   7. Globe Pipe Hanger Products, Inc.
   8. Grinnell Corp.
   9. GS Metals Corp.
   10. National Pipe Hanger Corporation.
   11. PHD Manufacturing, Inc.
   12. PHS Industries, Inc.
   13. Piping Technology & Products, Inc.
   14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.03 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bol3ts.

2.04 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:
   1. B-Line Systems, Inc.; a division of Cooper Industries.
   2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   3. GS Metals Corp.
   4. Power-Strut Div.; Tyco International, Ltd.
   5. Thomas & Betts Corporation.
   6. Tolco Inc.
   7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.05 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Available manufacturers:
   1. Carpenter & Paterson, Inc.
   2. ERICO/Michigan Hanger Co.
   3. PHS Industries, Inc.
   4. Pipe Shields, Inc.
   5. Rilco Manufacturing Company, Inc.
   6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.06 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Available Manufacturers:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Masterset Fastening Systems, Inc.
      d. MKT Fastening, LLC.
      e. Powers Fasteners.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Available Manufacturers:
      a. B-Line Systems, Inc.; a division of Cooper Industries.
      b. Empire Industries, Inc.
      c. Hilti, Inc.
      d. ITW Ramset/Red Head.
      e. MKT Fastening, LLC.
      f. Powers Fasteners.

2.07 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
   1. Available Manufacturers:
      a. ERICO/Michigan Hanger Co.
      b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
   1. Available Manufacturers:
      a. MIRO Industries.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   1. Available Manufacturers:
      a. ERICO/Michigan Hanger Co.
      b. MIRO Industries.
      c. Portable Pipe Hangers.
   2. Base: Stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   1. Available Manufacturers:
      a. Portable Pipe Hangers.
   2. Bases: One or more plastic.
   3. Vertical Members: Two or more protective-coated-steel channels.
   4. Horizontal Member: Protective-coated-steel channel.
   5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.08 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Available Manufacturers:
   1. C & S Mfg. Corp.
   2. HOLDRITE Corp.; Hubbard Enterprises.
   3. Samco Stamping, Inc.

2.09 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.10 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Pipe guides shall not be used as supports.

G. In no case shall wire or perforated strap be used for pipe or conduit support.

H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
   3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

M. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

N. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

O. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

P. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

Q. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.02 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricated from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:
1. Pipe Stand Types: Assemble components and mount on smooth surface.

I. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

J. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

K. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 8 and Larger: Include wood inserts.
   6. Insert Material: Length at least as long as protective shield.
   7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.06 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 22 05 48 - VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Freestanding and restrained spring isolators.
   5. Housed spring mounts.
   6. Elastomeric hangers.
   7. Spring hangers.
   8. Spring hangers with vertical-limit stops.
   9. Pipe riser resilient supports.
   10. Resilient pipe guides.
   11. Restraining braces and cables.
   12. Steel and inertia, vibration isolation equipment bases.

1.02 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Welding certificates.

C. Qualification Data: Reviewed and stamped by a professional engineer.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 PRODUCTS

2.01 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ace Mountings Co., Inc.
   2. Amber/Booth Company, Inc.
   3. California Dynamics Corporation.
   4. Isolation Technology, Inc.
   5. Kinetics Noise Control.
   6. Mason Industries.
   7. Vibration Eliminator Co., Inc.

8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

F. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

G. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

H. Pipe Riser Resilient Support : All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

I. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.02 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation.
8. Vibration Mountings & Controls, Inc.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inchlearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.03 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

3.03 VIBRATION-CONTROL INSTALLATION

A. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.

B. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

G. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.04 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of sprint isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.03 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.04 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. All major Plumbing equipment, including is properly identified with equipment identification, equipment controlled, electrical ratings and date of installation.
2. For miscellaneous equipment requiring access such as valves, access doors, etc., provide a ¾” colored adhesive button on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the button on an adjacent vertical surface (location approved by the engineer) or on the access panel for that piece of equipment. Button colors shall be as follows; Plumbing - Green.
3. Material and Thickness: Equipment should be clearly identified with engraved phenolic nameplates securely fastened to the equipment with sheet metal screws. Equipment name/numbers shall be the same as shown in the contract documents and the BAS Control drawings. Nameplates smaller than 4” by 2” shall only be allowed with approval from the designer.
4. Letter Color: Black
5. Background Color: White
6. Minimum Label Size: Shall be a minimum 4” by 2”.
7. Minimum Letter Size: ½” minimum.
8. Fasteners: Sheet metal screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Identification shall be provided as follows: no further than 30 feet apart, at major changes in direction, at each valve or equipment, and on both sides of penetrations.

B. Pipe Labels: Provide stencil or strap-on identification indicating the system and the direction of flow.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Completely paint piping systems in mechanical rooms and penthouse with applicable colors listed below.
   2. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   3. Lettering Size: At least 1/2 inches high.

D. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.

E. For insulated and un-insulated pipe systems, stencil sizes are as follows:
   1. For pipes up to 1 inch, use ½ inch letters, 8” wide color band.
   2. For pipes >1 inch to 2 inches, use ¾ inch letters, 8” wide color band.
   3. For pipes >2 inches to 4 inches, use 1 ¼ inch letters, 12” wide color band.
   4. For pipes >4 inches to 6 inches, use 1 ¼ inch letter, 12” wide color band.
   5. For pipes above 6 inches, use 4 inch letters, 24” wide color band.

2.04 VALVE TAGS

A. Valve Tags: Stamped or engraved.
   1. Tag Material: Brass valve tags, minimum 1.5” diameter, minimum ¼: high lettering for the service matching the chart in paragraph b. above, minimum ½” high lettering indicating valve number, with brass or stainless steel chains for all isolation, branch and control valves.

2. Valve tag chart to be included in the O&M manual.
3. Valve tag chart to be mounted in all ME rooms in a frame with lexan cover.
4. Include the tag numbers in the as-built drawings and record drawings.
5. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inchbond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data and framed under a rigid plastic cover in each of the mechanical rooms and penthouse. Locate framed valve tag schedule adjacent to the door of the mechanical room and penthouse.

2.05 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
1. Size: 3 by 5-1/4 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of plumbing equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 30 feet along each run in concealed and un-concealed areas.
7. Controls conduit shall be specified as factory painted.
8. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
9. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.
10. For insulated and un-insulated pipe systems, stencil sizes are as follow:
a. For pipes up to 1 inch, use ½ inch letters, 8” wide color band.
b. For pipes >1 inch to 2 inches, use ¾ inch letters, 8” wide color band.
c. For pipes >2 inches to 4 inches, use 1 ¼ inch letters, 12: wide color band.
d. For pipes >4 inches to 6 inches, use 1 ¼ inch letters, 12” wide color band.
e. For pipes above 6 inches, use 4 inch letters, 24” wide color band.

3.04 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Cold Water: 1-1/2 inches, round.
      b. Hot Water: 1-1/2 inches, round.
   2. Valve-Tag Color:
      a. Cold Water: Natural.
      b. Hot Water: Natural.
   3. Letter Color:
      a. Cold Water: Black.
      b. Hot Water: Black.

3.05 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.06 CEILING-TAG INSTALLATION

A. For serviceable equipment and valves located above an acoustical lay-in ceiling, provide a clear adhesive label on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the ceiling access panel for that piece of equipment. The label shall indicate the equipment designation in black text with minimum 3/8” high lettering.

B. For miscellaneous equipment requiring access such as valves, control dampers, access doors, multichannel transformers, and BAS Network switches, etc., provide a ¾” colored adhesive button on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the access panel for that piece of equipment. Button colors shall be as follows; Plumbing-Green.

3.07 COLOR CODING

A. Completely paint piping systems in mechanical rooms and the penthouse with the applicable colors listed below.

B. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.

C. The system colors and identifications are as follows:

Pipe/Duct System	Pipe/Duct Color	Identification	Label Color	Lettering Color
Domestic Cold Water	Dark Green	DOM CW	Green	White
Lab Cold Water	Light Blue	LAB CW	Light Blue	White
Deionized Water	Slate Gray	DSTW	Green	White
Domestic Hot Water	Light Orange	DHW	Green	White

Lab Hot Water	Dark Yellow	LAB HW	Dark Yellow	Black
Domestic HW Recirculating	Light Orange	DHWR	Green	White
Lab Hot Water Recirculating	Dark Yellow	LAB HWR	Dark Yellow	Black
Reclaim Water	Purple	RECLAIM	Yellow	Black
Sanitary Drainage & Vent	Same as surrounding area			
Air	Dark Gray	AIR	Green	White
Nitrogen	Pastel Gray	NITROGEN	Green	White
Vacuum	Beige	VAC	Green	White
Compressed Air	Gray	CA	Blue	White

Notes:

(1) White jacketing applies to insulated, non-concealed ductwork.

(2) Controls conduit shall be specified as factory painted.

END OF SECTION

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR PLUMBING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Testing, Adjusting, and Balancing of Plumbing Systems:
      a. Domestic hot-water in-line circulation pumps.
   2. Pipe leakage tests verification.

1.02 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: The TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report as specified in Part 3.

C. System Readiness Checklists as specified in "Preparation" Article.

D. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

E. Certified TAB reports.

F. Sample report forms.

G. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.04 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC or NEBB:
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

D. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.05 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, BAS provider, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Coordinate efforts with the project Commissioning Agent. Refer to commissioning specifications for additional information.

C. Provide seven days' advance notice for each test. Include scheduled test dates and times.

D. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.06 FIELD CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Final Acceptance. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.07 WARRANTY

A. Performance Warranty:
   1. If AABC standards are used, provide a warranty on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
   2. If NEBB standards are used, provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.

B. Warranty includes the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing valves and fittings. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine approved submittals for plumbing systems and equipment.

D. Examine design data, including plumbing system descriptions.

E. Examine equipment performance data, including pump curves.
   1. Relate performance data to Project conditions and requirements, including pump system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate pump system-effect factors to reduce performance ratings of plumbing equipment when installed under conditions different from the conditions used to rate equipment performance. Compare results with the design data and installed conditions.

F. Examine system and equipment installations.

G. Examine system pumps to ensure absence of entrained air in the suction piping.

H. Examine operating safety interlocks and controls on plumbing equipment.

I. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes the following:
   1. Strategies and step-by-step procedures for balancing the systems.
   2. Instrumentation to be used.
   3. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of plumbing systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
   1. Domestic Water System:
      a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed in accordance with applicable code and authority having jurisdiction.
      b. Water heaters are installed and functioning.
      c. Piping is complete and all points of outlet are installed.
      d. Water treatment is complete.
      e. Systems are flushed, filled, and air purged.
      f. Strainers are clean.
      g. Shutoff and balance valves are 100 percent open.
      h. Booster and hot-water circulating pumps are operational and proper rotation is verified.
      i. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 and in this Section.

B. Cut insulation, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
   1. Where holes for probes are required in piping or equipment, install pressure and temperature test plugs to seal systems.
   2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 22 07 00 “Plumbing Insulation."

C. Mark equipment and balancing devices, including valve position indicators and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR PLUMBING EQUIPMENT

A. Test, adjust, and balance plumbing equipment indicated on Drawings, including, but not limited to, the following:
   1. Domestic water in-line pumps.

3.05 PROCEDURES FOR DOMESTIC HOT-WATER CIRCULATING INLINE PUMP

A. Balance system with manual or automatic balancing valves by setting at design flow.
   1. Measure flow in main and branch pipes.
   2. Adjust main and branch balance valves for design flow.
   3. Re-measure each main and branch after all have been adjusted.

B. Adjust pump to deliver total design flow.
   1. Measure pump TDH as follows:
      a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.

2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
3. Mark final settings and verify that all memory stops have been set.
4. Verify final system conditions as follows:
   a. Re-measure and confirm that total flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
   c. Mark final settings.

3.06 TOLERANCES

A. Set plumbing system's flow rates within the following tolerances:
   1. Domestic Hot-Water Rate: Plus 10 percent.

3.07 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents, including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Notes to explain why certain final data in the body of reports vary from indicated values.
   14. Test conditions for pump performance forms.

D. System Diagrams: Include schematic layouts of distribution systems. Present each system with single-line diagram and include the following:
   1. Flow rates.

2. Pipe and valve sizes and locations.
3. Balancing stations.
4. Position of balancing devices.

E. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Service.
      d. Make and size.
      e. Model number and serial number.
      f. Water flow rate in gpm.
      g. Water-pressure differential in feet of head or psig.
      h. Pump speed.
      i. Impeller diameter in inches.
      j. Motor make and frame size.
      k. Motor horsepower and rpm.
      l. Voltage at each connection.
      m. Amperage for each phase.
      n. Full-load amperage and service factor.
      o. Seal type.
   2. Test Data (Indicated and Actual Values):
      a. Static head in feet of head or psig.
      b. Pump shutoff pressure in feet of head or psig.
      c. Actual impeller size in inches.
      d. Full-open flow rate in gpm.
      e. Full-open pressure in feet of head or psig.
      f. Final discharge pressure in feet of head or psig.
      g. Final suction pressure in feet of head or psig.
      h. Final total pressure in feet of head or psig.
      i. Final water flow rate in gpm.
      j. Voltage at each connection.
      k. Amperage for each phase.

F. Instrument Calibration Reports:
   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.08 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of the Architect, Owner’s representative, or Commissioning authority.

B. Architect, Owner’s representative, or Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:
   1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

F. Prepare test and inspection reports.

END OF SECTION

SECTION 22 07 00 - PLUMBING INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Insulation Materials:
      a. Flexible elastomeric.
      b. Mineral fiber.
   2. Insulating cements.
   3. Adhesives.
   4. Mastics.
   5. Lagging adhesives.
   6. Sealants.
   7. Factory-applied jackets.
   8. Field-applied fabric-reinforcing mesh.
   9. Field-applied cloths.
   10. Field-applied jackets.
   11. Tapes.
   12. Securements.
   13. Corner angles.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties, equipment connections, and access panels.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.
   8. Detail field application for each equipment type.

C. Qualification Data: For qualified Installer.

D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

E. Field quality-control reports.

F. Sustainability Submittals:
   1. Product Data: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

1.03 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
3. Field applied mesh cloth and jackets shall be enhanced or treated with fire retardant coatings.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.05 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.06 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 PRODUCTS

2.01 INSULATION MATERIALS

A. All insulation shall meet or exceed North Carolina Energy Code. All piping shall no exceed a thermal conductivity of 0.27 BTU per inch/hxft^{2}xF

B. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

C. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000(Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.
      e. Owens Corning; Fiberglas Pipe Insulation.
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   4. Manholes.
   5. Handholes.
   6. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Division 07 Section "Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Firestopping."

3.05 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
   2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   3. Protect exposed corners with secured corner angles.
   4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      a. Do not weld anchor pins to ASME-labeled pressure vessels.
      b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
      d. Do not over compress insulation during installation.
      e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.

f. Impale insulation over anchor pins and attach speed washers.
g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.06 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced

without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.07 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.08 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.09 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color to meet Wake Tech Design Guidelines. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
1. Inspect field-insulated equipment, randomly selected by Designer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

2. Inspect pipe, fittings, strainers, and valves, randomly selected by Designer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Domestic hot-water storage tank insulation shall be the following, of thickness to provide an R-value of 12.5:
1. Mineral Fiber.

3.13 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Underground cold water piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Water Pipe (Cold and Non-Portable Water):
1. Insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch thick for pipe 1-1/2” or below, 1-1/2 inch thick for pipe greater than 1-1/2”.

B. Domestic Water Pipe (Hot and Re-circulating):
1. Insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch thick for pipe 1-1/2” or below, 1-1/2 inch thick for pipe greater than 1-1/2”.
b. Mineral-Fiber, Preformed Pipe Insulation: 1 inch thick for pipe 1-1/2” or below, 1-1/2 inch thick for pipe greater than 1-1/2”.

C. Stormwater and Overflow:
1. All pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric, Preformed Pipe Insulation, Type I: 1 inch thick for pipe 1-1/2” or below, 1-1/2 inch thick for pipe greater than 1-1/2”.

D. Roof Drain and Overflow Drain Bodies:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric, Preformed Pipe Insulation, Type I: 1 inch thick for pipe 1-1/2” or below, 1-1/2 inch thick for pipe greater than 1-1/2”.

E. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water or the nearest vertical connection, whichever is further.
1. All Pipe Sizes: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick for pipe 1-1/2” or below, 1-1/2 inch thick for pipe greater than 1-1/2”.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Exposed Piping:
   1. PVC: 30 mils thick. Provide color-coded jackets per Specification Section 22 05 53.

END OF SECTION

SECTION 22 08 13 - COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The purpose of this section is to specify the Division 22 contractor responsibilities in the commissioning (Cx) process.

B. Commissioning requires the participation of the Division 22 contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019113, General Commissioning Requirements. The Division 22 contractor shall be familiar with all parts of Section 019113 and the Cx Plan issued by the Commissioning Authority (CxA) and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

C. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:

1. Plumbing (1.5.1A.1D)
    a. Electric water heater
    b. Plate and frame heat exchanger
    c. Recirculation pump

1.3 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process, as specifically related to the plumbing systems, are provided in this section.

D. Refer to Section 019113 and the Cx Plan for all typical commissioning process requirements for each team member.

E. Each Contractor and subcontractor shall review this Section and shall include in their bids cost for carrying out the work described, as it applies to each Division and Section of these specifications, individually and collectively.

F. The commissioning responsibilities applicable to the contractors of Division 22 are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

1. Include the cost of commissioning work in the contract price.
2. Attend a commissioning kick-off meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process, as indicated in specification section 019113.
3. Contractors shall provide the CxA with cut sheets and shop drawing submittals of commissioned equipment to the CxA.
4. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of Pre-Functional Checklists (PFC) and Functional Performance Testing (FPT) procedures.

a. Typically, this will include detailed manufacturer installation and startup, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.

b. The CxA may request further documentation necessary for the commissioning process.

5. Provide a copy of the equipment submittals of commissioned equipment, through normal channels, to the CxA for review and comment.
6. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
7. Provide assistance to the CxA in preparation of the specific FPT procedures listed in the Cx Plan (prepared by the CxA), Section 019113 and this section. Contractor shall review test procedures to ensure feasibility, safety and equipment protection.
8. Develop a full startup and initial checkout plan using manufacturer's startup procedures. Submit manufacturer's detailed startup procedures and the full startup plan and procedures and other requested equipment documentation to CxA for review and comment.
9. During the startup and initial checkout process, execute and document the plumbing-related portions of the PFCs provided by the CxA in the online commissioning portal, CxAlloy, for all commissioned equipment.
10. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
11. Address current A/E punch list items before functional testing.
12. Provide skilled technicians to execute starting of equipment and to execute the FPTs. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
13. Perform FPT under the direction of the CxA for specified equipment in the Cx Plan, this Section and Section 019113. Assist the CxA in interpreting the monitoring data, as necessary.
14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, OR and A/E and retest the equipment.
15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
16. During construction, maintain hard copy and CAD as-built red-line drawings for all drawings and provide final record drawings for all owner and contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).
17. Provide training of the Owner's operating personnel as specified.
18. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.
2. Correct deficiencies and make necessary adjustments to O&M manuals and record drawings for applicable issues identified in any seasonal testing.
3. Participate in the near-warranty end (ten month) post occupancy visit.

1.4 RELATED WORK

A. Refer to Section 019113 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 019113 for all systems to be commissioned.

1.5 SUBMITTALS

A. Division 22 shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 019113 for additional Division 22 requirements.

1.6 WEB-BASED COMMISSIONING PORTAL

A. All general and major contractors participating in the Cx process shall use the web-based Cx Portal, CxAlloy (“Portal” or “CxAlloy”) to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store PFCs, Startup Documentation, FPTs and results, Issues Log tracking, project documents and deliverables. It so serves as a collaborative e-mail hub to facilitate, automate, and track communications between Parties relating to the Cx process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Division 22 contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 019113 for additional Division 22 test equipment requirements.

C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the contractor. The manufacturer shall provide the test equipment, demonstrate its use and assist the CxA in the Cx process.

2.2 INCIDENTAL EQUIPMENT

A. The Division 22 contractor shall provide all scaffolds, staging, ladders and accessories required to allow testing agencies, consultants and Owner’s staff safe access to equipment, valves and other devices located above floor level.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Section 019113 for additional meeting requirements.

D. Participation at various commissioning meetings shall depend on the purpose of the meeting and may consist of, but not be limited to, the following members of the project commissioning team: the Owner’s representative (i.e. project manager and/or facility staff), the CxA, the Construction Manager (CM) or General Contractor (GC), subcontractors and/or manufacturer’s

technical representative as required, the architect/engineer (A/E), and any specialists deemed appropriate by the Cx team.

E. All the listed Cx team members shall participate in the Cx kick-off meeting.

F. Participate, as applicable, in Cx coordination meetings in accordance with related Section 019113.

G. Participate, as needed, in deficiency resolution meetings.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. Sampling Strategy: 100% of commissioned systems and equipment shall have PFCs completed and submitted for review and approval prior to FPT. The CxA may observe the Division 22 contractor's completion of the PFCs.

B. Typical aspects of plumbing PFCs verify that the equipment matches the approved submittal, is installed properly, is started-up (and startup is documented) and integrated disciplines (i.e. electrical, equipment vendors, controls) have completed their work required for the equipment and system to function in its entirety. Examples would include spot checking of wiring/termination point-to-points and verification of alarm point parameters and messages.

3.3 STARTUP

A. The plumbing contractor shall follow the startup, initial checkout procedures, and PFCs for the equipment and systems listed in the Summary in this section and Section 019113. The Division 22 contractor has startup responsibility and is required to complete systems and sub-systems, so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility to the CxA or Owner.

B. FPT is intended to begin upon completion of a system. FPT will not proceed prior to the completion of systems, or sub-systems, which includes completion and approval of any necessary testing, adjusting and balancing (TAB) requirements.

3.4 CALIBRATION

A. Sensor and actuator calibration and calibration methods are covered in Section 019113 and other Division 22 Sections and are the responsibility of the Division 22 contractor.

3.5 TESTING PREPARATION

A. Inspect and verify the position of each device and interlock identified on checklists.

B. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, started, quality control tested, and code tested (as applicable) and are operating according to the Contract Documents.

C. Certify that plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest setpoints have been recorded.

D. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved by the Engineer of Record.

E. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.6 FUNCTIONAL PERFORMANCE TESTS

A. FPT is intended to begin upon completion of PFCs. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and Owner. Beginning system testing before full completion does not relieve the Contractor from fully completing the system.

C. Refer to Section 019113 for a complete list of systems to be commissioned and a description of the process.

D. Sampling Strategy

1. Plumbing (1.5.1A.1D)
    a. Electric water heater (1 of 1)
    b. Plate and frame heat exchanger (1 of 1)
    c. Recirculation pump

E. Refer to Section 019113, Sampling for the Sampling/Failure Rule.

F. Typical aspects of plumbing FPTs verify that systems, subsystems and equipment function interactively and throughout the full range of operating conditions (e.g., low load, design load, component failures, alarm conditions, safety interlocks including with life safety systems, etc.) and modes (e.g. normal shutdown, normal auto position, normal manual position, power failure including control power, emergency power, unoccupied, fire alarm, etc.). The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Positive confirmation of state/status shall be shown both locally and via the BAS, as specified in the Contract Documents.

G. Development of Test Procedures: Before test procedures are written, the CxA shall obtain project contract documentation and a current list of change orders and RFI's affecting equipment or systems, including an updated points list, program code, control sequences and parameters and electrical coordination study. The CxA shall develop specific test procedures and forms for evaluating performance of all integral components and their functioning as a complete unit within design requirements and manufacturer's published data. Prior to execution, the CxA shall provide a copy of the test procedures to the Contractors who shall review the tests for feasibility, safety, equipment and warranty protection.

3.7 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 019113 for specific details on non-conformance issues relating to tests.

B. Refer to Section 019113 for issues relating to functional performance tests.

3.8 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. Division 22 contractor shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver to the CM for inclusion in the O&M manuals.

C. The CxA shall receive a copy of the O&M manuals for concurrent review and comment with the A/E.

3.9 TRAINING OF OWNER PERSONNEL

A. Training shall be in accordance with ASHRAE Standard 202-2018, Commissioning Process for Buildings and Systems, and ASHRAE Guideline 0-2019, The Commissioning Process.

B. The CM/GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed in accordance with Division 1 requirements. Refer to Section 019113 for additional details.

C. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 019113 for additional details.

D. The Division 22 contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan a minimum of eight (8) weeks before the planned training according to the outline described in Section 019113.
2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned plumbing equipment or system.
3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the startup technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation for the specific piece of equipment are required. More than one party may be required to execute the training.
6. The training sessions shall follow the outline in the Table of Contents of the O&M manual and illustrate whenever possible the use of the O&M manuals for reference.
7. Training shall include:
8. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
9. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include startup, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
10. Discuss relevant health and safety issues and concerns.
11. Discuss warranties and guarantees.
12. Cover common troubleshooting problems and solutions.
13. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
14. Discuss any peculiarities of equipment installation or operation.

E. Hands-on training shall include startup, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance of all pieces of equipment.

F. The Division 22 contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the BAS.

G. Training shall occur after functional testing is complete, unless approved otherwise by the Owner's Representative and CxA.

3.10 DEFERRED TESTING

A. Refer to Section 019113 for requirements of deferred testing.

3.11 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the startup and initial checkout plan described in Section 019113 and the completed startup, and initial checkout.

END OF SECTION 220813

SECTION 22 11 16 - DOMESTIC WATER PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.

1.02 SUBMITTALS

A. Product Data: For the following products:
   1. Specialty valves.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Flexible connectors.
   5. Water penetration systems
   6. Water Meters.

B. Water Samples: Specified in "Cleaning" Article.

C. Field quality-control reports.

1.03 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.

C. Comply with NSF 61 for potable domestic water piping and components.

1.04 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Designer and Owner no fewer than five days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Owner's written permission.

1.05 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 PRODUCTS

2.01 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
   1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
   2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
   4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.02 STEEL PIPING

A. 4 inch and larger optional: Schedule 40 galvanized steel pipe with galvanized cast iron fittings and threaded joints.

2.03 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook." No joints shall be installed below slab.

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41. This occurs at the building service entrance only.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves.

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

K. Install piping adjacent to equipment and specialties to allow service and maintenance.

L. Install piping to permit valve servicing.

M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

N. Install piping free of sags and bends.

O. Install fittings for changes in direction and branch connections.

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump.

R. Install thermostats in hot-water circulation piping.

S. Install thermometers on inlet and outlet piping from each water heater except point of use water heaters.

T. Install sleeves for piping penetrations of walls, ceilings, and floors.

U. Install sleeve seals for piping penetrations of concrete walls and slabs.

V. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.02 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.03 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
   1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
   2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

3.04 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings.

3.05 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings.

3.06 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.07 WATER METER INSTALLATION

A. Rough-in domestic water piping for water meter installation and install water meters according to Wake Technical Community College requirements.

B. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.

C. Install remote registration system according to Wake Technical Community College standards.

3.08 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
   1. Vertical Piping: MSS Type 8 or 42 clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.
   7. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

3.09 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
   4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.10 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections, and arrange for reinspection.
   4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
   1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   4. Cap and subject piping to static water pressure of 100 psig, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
   6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
      a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
      b. Adjust calibrated balancing valves to flows indicated.
   5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
   6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
   7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
   8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.13 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
      c. Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
         1) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
      d. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      e. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

D. Water supply shall not be placed into a service until bacteriological test results of representative water samples analyzed by an approved laboratory are found to be satisfactory. Contractor shall engage an independent laboratory to conduct bacteriological and post-chlorination test certifying that the water meets EPA quality of the drinking water. The “Water Test Report for Use,” after accepted by the Engineers of Record, is required to be submitted to SCO prior sending request for Final Inspection and Occupancy Permit.

3.14 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building service piping, NPS 3 and smaller, shall be the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints.

D. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be the following:
   1. Mechanical-joint, ductile-iron pipe; standard- pattern mechanical-joint fittings; and mechanical joints.

E. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:
   1. Copper tube, ASTM B 88, Type L; no fittings.

F. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:
   1. Hard copper tube, ASTM B 88, Type L; wrought- copper solder-joint fittings; and soldered joints.

G. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; wrought- copper solder-joint fittings; and soldered joints.
   2. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.

END OF SECTION

SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following domestic water piping specialties:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Water pressure-reducing valves.
   4. Balancing valves.
   5. Strainers.
   6. Outlet boxes.
   7. Hose bibbs.
   8. Wall hydrants.
   9. Water hammer arresters.
   10. Air vents.
   11. Trap-seal primer valves.

1.02 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
   1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 PRODUCTS

2.01 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. FEBCO; SPX Valves & Controls.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Plumbing Products group; Wilkins Div.
   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Body: Bronze.

5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrowhead Brass Products, Inc.
   b. Cash Acme.
   c. Conbraco Industries, Inc.
   d. Legend Valve.
   e. MIFAB, Inc.
   f. Prier Products, Inc.
   g. Watts Industries, Inc.; Water Products Div.
   h. Woodford Manufacturing Company.
   i. Zurn Plumbing Product Group; Light Commercial Operation.
   j. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1011 and AWVA C510.
3. Body: Bronze, non-removable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Chrome or nickel plated.

2.02 BACKFLOW PREVENTERS

A. Double-Check Backflow-Prevention Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ames Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Watts Industries, Inc.; Water Products Div.
   e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

B. Reduced-Pressure Principle Backflow-Prevention Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ames Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Watts Industries, Inc.; Water Products Div.
   e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Size: 1-1/2 NPS & 3 NPS
6. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
8. Configuration: Designed for horizontal, straight through flow.
9. Accessories:

a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Backflow-Preventer Test Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conbraco Industries, Inc.
b. FEBCO; SPX Valves & Controls
c. Flomatic Corporation.
d. Watts Industries, Inc.; Water Products Div.
e. Zurn Plumbing Products Group; Wilkins Div.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.03 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conbraco Industries, Inc.
b. Watts Industries, Inc.; Water Products Div.
c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Body: Bronze for NPS 2and smaller; cast iron for NPS 2-1/2 and NPS 4.
5. Valves for Booster Heater Water Supply: Include integral bypass.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.04 BALANCING VALVES

A. Automatic Flow Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equal:
a. ICSS by AIMI Flow Design.
2. Construction: Series 300 stainless steel, nickel plated brass union nut, series 300 stainless steel flow cartridge. NSF-61-G certified
3. Calibration: Control within 5 percent of design flow over 95% control range.

2.05 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
a. Strainers NPS 2 and Smaller: 0.020 inch.
b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
c. Strainers NPS 5 and Larger: 0.10 inch.
6. Drain: Factory-installed, hose-end drain valve.

2.06 OUTLET BOXES

A. Icemaker Outlet Boxes:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Acorn Engineering Company.
b. IPS Corporation.
c. LSP Products Group, Inc.

d. Oatey.
e. Plastic Oddities; a division of Diverse Corporate Technologies.
2. Mounting: Recessed.
3. Material and Finish: Enameled-steel or epoxy-painted-steel.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.07 HOSE BIBBS

A. Hose Bibbs:
1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include wall flange with each chrome- or nickel-plated hose bibb.

2.08 WALL HYDRANTS

A. Non-freeze Wall Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Josam Company.
b. MIFAB, Inc.
c. Prier Products, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Woodford Manufacturing Company.
h. Zurn Plumbing Products Group; Light Commercial Operation.
i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys(s): One with each wall hydrant.

2.09 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AMTROL, Inc.
b. Josam Company.
c. MIFAB, Inc.
d. PPP Inc.
e. Sioux Chief Manufacturing Company, Inc.
f. Smith, Jay R. Mfg, Co.; Division of Smith Industries, Inc.
g. Tyler Pipe; Wade Div.
h. Watts Drainage Products Inc.
i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.10 AIR VENTS

A. Bolted-Construction Automatic Air Vents:
1. Body: Bronze.
2. Pressure Rating: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.11 ELECTRONIC TRAP-SEAL PRIMER SYSTEM

A. Electronic Trap-Seal Primer Valve Assembly:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Zurn Plumbing Products Group; Specification Drainage Operation.
b. Sioux Chief Manufacturing Company, Inc.
c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
d. Watts Industries, Inc.; Water Products Div
2. Cabinet: Recessed.
3. Material and Finish: Galvanized Steel.
4. Power: 120-24 VAC transformer powering a 24 VAC slow-closing valve
5. Standard: ASSE 1044.
6. Vacuum Breaker: ASSE 1001.
7. Pressure Rating: 3 psig minimum & 100 psig maximum.
8. Inlet Connection: NPS 1/2 solder joint.
9. Outlet Connection: NPS 1/2 Male PEX connections.
10. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120 V AC power.
a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
11. Electronic trap primer to be capable of supplying 5 to 10 traps from a single primer assembly. To provide a 6 second water injection to traps every 24 hours.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

C. Install water control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

F. Install outlet boxes recessed in wall. Install blocking wall reinforcement between studs.

G. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
1. Install shutoff valve on outlet if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified. Install blocking wall reinforcement between studs.

H. Install water hammer arresters in water piping according to PDI-WH 201.

I. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

J. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

K. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm’s length.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

3.03 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
1. Pressure vacuum breakers.
2. Reduced-pressure-principle backflow preventers.
3. Dual-check-valve backflow preventers.
4. Reduced-pressure-detector, fire-protection backflow-preventer assemblies.
5. Water pressure-reducing valves.
6. Calibrated balancing valves.
7. Primary, thermostatic, water mixing valves.
8. Outlet boxes.
9. Supply-type, trap-seal primer valves.
10. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
   1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.05 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION

SECTION 22 11 23 - DOMESTIC WATER PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic hot-water circulation:
   1. Wet rotor, inline pump

B. Related Requirements:
   1. Section 23 09 00 "Building Automation System" and drawings for pump interface to the building automation system.

1.02 SUBMITTALS

A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03

PART 2 PRODUCTS

2.01 INLINE PUMP

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett Series ecocirc-XL circulators or comparable product by one of the following:
   1. Armstrong Pumps Inc.
   2. Bell & Gossett Domestic Pump; ITT Corporation.
   3. Grundfos Pumps Corp.
   4. TACO Incorporated.

B. Description: High efficiency, in-line wet rotor circulation pump, UL 778 listed.

C. Capacities and Characteristics: Refer to equipment schedules on drawings for information.

D. Materials of Construction
   1. Pump Body: Lead Free Bronze
   2. Bearing: Carbon Sleeve
   3. Impeller: Poly-phenylene Sulfide

4. Seal: Watertight
5. Shaft: AISI 420 Stainless Steel

E. Operating Data
1. Maximum Working Pressure: 150 psi
2. Maximum Working Temperature: 200°F
3. Minimum Working Temperature: 40°F

F. Motor
1. Stator isolated from fluid through use of stainless steel can. Rotor shall be sheathed in stainless steel.
2. Synchronous, permanent-magnet (PM) motor. Tested with the pump as one unit. Conventional induction motors will not be acceptable.
3. Motor shall be non-overloading at any point on the pump curve and shall have built in overload protection.
4. Integrated variable frequency drive. Tested as one unit by the manufacturer.
5. Integrated motor protection shall be verified by UL to protect the pump against:
a. Over/under voltage
b. Over temperature of motor and/or electronics
c. Over current
d. Locked rotor
e. Dry run (no load condition).

G. Connections: Flange, see drawings for size.

H. The pump internals shall be capable of being serviced without disturbing piping connections.

I. Pump shall have BACnet IP connection capability built into the VFD.

J. Pump Control
1. Provide BACnet IP interface to the building automation system. Coordinate requirements with BAS provider. Building automation system is specified in Section 23 09 00 "Building Automation System."
2. All control functions shall be provided remotely at the BAS through the network connection.
3. All monitoring data points which are available at the Integrated Variable Frequency Drive shall be provided remotely at the BAS through the network connection.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.02 PUMP INSTALLATION

A. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Install centrifugal pumps with motor and pump shafts horizontal.

D. Install continuous-thread hanger rods of sufficient size to support pump weight. Vibration isolation devices are specified in Division 22 Section "Vibration Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

3.03 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
   1. Install flexible connectors adjacent to pumps in suction and discharge piping
   2. Install shutoff valve and strainer on suction side of pumps, and check valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
   3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.

3.04 CONTROL CONNECTIONS

A. BAS contractor shall install control and electrical power wiring to field-mounted control devices.

B. BAS contractor shall connect control wiring between temperature controllers and devices.

3.05 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Set thermostats for automatic starting and stopping operation of pumps.
   5. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
   7. Start motor.
   8. Open discharge valve slowly.
   9. Adjust temperature settings on thermostats.
   10. Adjust timer settings.

END OF SECTION

SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
   3. Encasement for underground metal piping.

1.02 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.03 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.
   2. Sanitary Sewer, Force-Main Piping: 100 psig.

1.04 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:
   1. Coordination drawings.

C. Field quality-control inspection and test reports.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 PRODUCTS

2.01 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.02 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   1. Joints: ASTM C-1540 Heavy Duty neoprene gaskets and Type 304 Stainless Steel clamp and shield assemblies with 4 sealing clamps for pipe sizes 1 ½” thru 4” and 6 sealing clamps for pipe sizes 5” and larger.
      a. Available Manufacturers:
         1) ANACO.
         2) Fernco, Inc.
         3) Ideal Div.; Stant Corp.

4) Mission Rubber Co.
5) Tyler Pipe; Soil Pipe Div.

2.03 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Gaskets: AWWA C111, rubber.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.04 PLASTIC PIPE

A. Piping: Schedule 40 solid wall polyvinyl chloride (PVC) material, ASTM D2665; ASTM D1785.

B. Fittings: PVC, ASTM D2665.

C. Joints: ASTM D2855; solvent weld with ASTM D2564 solvent cement.

PART 3 EXECUTION

3.01 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping shall be the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings, heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

C. Aboveground, vent piping shall be the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

D. Underground, soil, waste, and vent piping shall be the following:
   1. Solid wall Schedule 40 PVC pipe, PVC socket fittings, and solvent-cemented joints.

E. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
   1. Steel pipe, pressure fittings, and threaded joints.

3.02 PIPING INSTALLATION

A. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

B. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

D. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

E. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn,

double Y-branch and 1/8-bend fittings if 2 fixtures are installed back-to-back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change the direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing the size of drainage piping in direction of flow is prohibited.

F. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

G. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

J. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing.

K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.03 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

C. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.04 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.
   2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.05 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Install individual, straight, horizontal piping runs according to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

D. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 60 inches with 3/4-inch rod.

E. Install supports for vertical cast-iron soil piping every 15 feet.

F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.

G. Install supports for vertical steel piping every 15 feet.

H. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 2: 84 inches with 3/8-inch rod.
   2. NPS 3: 96 inches with 1/2-inch rod.
   3. NPS 4: 108 inches with 1/2-inch rod.
   4. NPS 6: 10 feet with 5/8-inch rod.

I. Install supports for vertical stainless-steel piping every 10 feet.

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.
   4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   5. NPS 6: 10 feet with 5/8-inch rod.
   6. NPS 8: 10 feet with 3/4-inch rod.

K. Install supports for vertical copper tubing every 10 feet.

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.06 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:
   1. Sanitary Sewer: To exterior force main or sanitary manhole.
   2. Sewage Pumps: To sewage pump discharge.

3.07 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections, and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout the period of inspection. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained. Caulking of welded or screwed joints, cracks, or holes is not acceptable. Correct leaks in screwed sittings by remarking joints. Cut out and reweld.
   6. Prepare reports for tests and require corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and require corrective action.

3.08 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during the remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.09 PROTECTION

A. During construction all openings in piping shall be closed with caps or plugs to keep out all foreign matter.

END OF SECTION

SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Miscellaneous sanitary drainage piping specialties.
   4. Flashing materials.

1.02 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof penetrations.

PART 2 PRODUCTS

2.01 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.

e. Watts Drainage Products Inc.
f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug or Stainless-steel plug with seal.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Josam Company; Josam Div.
b. Oatey.
c. Sioux Chief Manufacturing Company, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Zurn Plumbing Products Group; Light Commercial Operation.
h. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Josam Company; Josam Div.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.
f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Round, nickel-bronze wall-installation frame and cover.

2.02 FLOOR DRAINS

A. Cast-Iron Floor Drains – Basis of design model numbers: Toilet Rooms/EW-1: Zurn Model No. ZN415B-P-Y; Mechanical Rooms: Zurn Model No. ZN508-P-Y; Indirect Drainage: Zurn Model No. ZN415I-P-Y; Indirect with Funnel: Zurn Model No. ZZZ.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Zurn Plumbing Products Group; Light Commercial Operation.
b. Zurn Plumbing Products Group; Specification Drainage Operation.

c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
d. Josam Company; Josam Div.
e. MIFAB, Inc.
f. Prier Products, Inc.
g. Tyler Pipe; Wade Div.
h. Watts Drainage Products Inc.
i. Commercial Enameling Co.

2. Body Material: Gray iron.
3. Anchor Flange: Required.
4. Clamping Device: Required.
5. Outlet: Bottom.
6. Top or Strainer Material: Nickel bronze.
7. Top of Body and Strainer Finish: Nickel bronze.
8. Top Shape: Round.
9. Trap Material: Cast iron.
10. Trap Pattern: Deep-seal P-trap.
11. Trap Features: Trap-seal primer valve drain connection – where indicated.

2.03 FLOOR SINKS:

A. Floor Sinks-stainless steel: Josam 762-300 or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.
5. Cleanouts shall consist of Y branches with cleanout plugs and covers.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
5. Drains installed in water-proofing membranes shall have a flashing clamp device.

E. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

F. Assemble open drain fittings and install with top of hub 2 inches above floor.

G. Install deep-seal traps on floor drains and other waste outlets, if indicated.

H. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.

I. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

J. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

K. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

L. Install wood-blocking reinforcement for wall-mounting-type specialties.

M. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Grease interceptors.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to

identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.05 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 14 00 - FACILITY STORM DRAINAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Storm water piping buried within 5 feet of building.
   2. Storm water piping above grade.
   3. Bedding and cover materials.

1.02 SUBMITTALS

A. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes for sump-pumps, catch basins and manholes.

B. Product Data:
   1. Piping: Submit data on pipe materials, fittings, and accessories. Submit manufacturers catalog information.
   2. Storm Drainage Specialties: Submit manufacturers catalog information, component sizes, rough-in requirements, service sizes, and finishes.

1.03 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of equipment and clean-outs.

1.04 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.07 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.01 STORM WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. Cast Iron Pipe: ASTM A74, service weight, bell and spigot ends.
   1. Fittings: Cast iron, ASTM A74.
   2. Joints: Hub and spigot CISPI HSN compression type with ASTM C564, neoprene gasket system.

2.02 STORM WATER PIPING, ABOVE GRADE

A. Cast Iron Pipe: CISPI 301, hubless, service weight.
   1. Fittings: Cast iron, CISPI 301.
   2. Joints: ASTM C-1540 Heavy Duty neoprene gaskets and Type 304 stainless steel clamp and shield assemblies with 4 sealing clamps for pipe sizes 1-1/2” thru 4” and 6 sealing clamps for pipe sizes 5” and larger.

2.03 BEDDING AND COVER MATERIALS

A. Bedding cover and backfill are to be in accordance with the Sitework, Division 31 and 33, of the specifications and civil drawings drawing details.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.03 INSTALLATION - BURIED PIPING SYSTEMS

A. Verify connection size, location, and invert are as indicated on Drawings.

B. Establish elevations of buried piping with not less than 2 ft of cover.

C. Establish minimum separation from other services in accordance with the NC Plumbing Code.

D. Excavate pipe trench in accordance with the Sitework portion of the specifications and drawings.

E. Install pipe to elevation as indicated on Drawings.

F. Place bedding material at trench bottom to provide uniform bedding for piping, level bedding materials in one continuous layer not exceeding 4 inches compacted depth; compact to 95 percent maximum density.

G. Install pipe on prepared bedding.

H. Route pipe in straight line.

I. Install indicator tape continuous over top of pipe 6 inches below grade.

3.04 INSTALLATION - ABOVE GROUND PIPING

A. Establish invert elevations for slopes for drainage in accordance with the NC Plumbing code.

B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Provide clearance at cleanout for snaking drainage system.

C. Encase exterior cleanouts in concrete flush with grade.

D. Install floor cleanouts at elevation to accommodate finished floor.

E. Install non-conducting dielectric connections wherever jointing dissimilar metals.

F. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

G. Install piping to maintain headroom. Group piping to conserve space.

H. Group piping whenever practical at common elevations.

I. Support cast iron drainage piping at every joint.

J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

K. Provide clearance in hangers and from structure and other equipment for installation of insulation.

L. Install piping penetrating roofed areas to maintain integrity of roof assembly.

M. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding, or approved alternative method and maintain fire proofing where applicable.

N. For piping exposed in occupied areas, not in mechanical or electrical rooms, prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting.

O. Install bell and spigot pipe with bell end upstream.

P. Sleeve pipes passing through rated walls and all floors.

Q. Install firestopping at fire rated construction.

3.05 FIELD QUALITY CONTROL

A. Test storm drainage piping system in accordance with the NC Plumbing Code and the local authority having jurisdiction.

END OF SECTION

SECTION 22 14 23 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following storm drainage piping specialties:
   1. Cleanouts.
   2. Roof drains.
   3. Roof overflow draws.
   4. Miscellaneous storm drainage piping specialties.
   5. Flashing materials.

1.02 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PUR: Polyurethane plastic.

H. PVC: Polyvinyl chloride plastic.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

1.04 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.05 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 PRODUCTS

2.01 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Josam Company; Josam Div.
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.36.2M for cast-iron for cleanout test tee.
   3. Size: Same as connected drainage piping.
   4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping..
   5. Closure: Countersunk, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   7. Closure: Stainless-steel plug with seal.

B. Metal Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Josam Company; Josam Div.
b. Oatey.
c. Sioux Chief Manufacturing Company, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Zurn Plumbing Products Group; Light Commercial Operation.
h. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.
16. Housing: Stainless steel.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Josam Company; Josam Div.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.
f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hub-and-spigot, cast-iron soil pipe T-Branch as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, deep, chrome-plated bronze cover plate with screw.
8. Wall Access: Round, nickel-bronze, wall-installation frame and cover.

2.02 ROOF DRAINS

A. Metal Roof Drains: Zurn Model No. ZF100 roof drain, or approved equal.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Olympic Manufacturing Group.
b. Portals Plus, Inc.
c. Thaler Metal Industries Ltd.
d. Josam Company; Josam Div.
e. Marathon Roofing Products.
f. MIFAB, Inc.
g. Prier Products, Inc.
h. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
i. Tyler Pipe; Wade Div.

j. Watts Drainage Products Inc.
k. Zurn Plumbing Products Group; Light Commercial Operation.
l. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.2M.
3. Pattern: Roof drain.
4. Body Material: Cast iron.
5. Outlet: Bottom.
6. Dome Material: Cast iron.
7. Underdeck Clamp: Required.

B. Zurn ZF-100 15-inch diameter roof drain, dura-coated cast iron body and dome, combination membrane flashing clamp/gravel guard and low silhouette dome.

C. Overflow drains shall be the same as roof drains except that they shall have internal 2" standpipe for overflow.

2.03 DOWNSPOUT COVERS

A. Manufacturers:
1. Zurn.
2. Wade.
3. Josam.
4. Jay R. Smith.

B. Product Description: Zurn Z199-DC cover, perforated, hinged, type 304 stainless steel frame and strainer, vandal-proof secured top.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Position roof drains for easy access and maintenance.

E. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

F. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

G. Install manufactured, gray-iron downspout boots at grade with top 18 inches above grade. Secure to building wall.

H. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

I. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.03 FLASHING INSTALLATION

A. Coordinate with Division 07 sections.

3.04 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 14 29 - SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following sump pumps and accessories, inside the building, for building storm drainage systems:
   1. Submersible oil-sensing sump pumps.

B. Related Requirements:
   1. Section 23 09 00 "Building Automation System" and drawings for sump pump interface to the building automation system.

1.02 SUBMITTALS

A. Product Data: For each type and size of sump pump specified. Include certified performance curves with operating points plotted on curves, and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For each sump pump to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sump pumps and are based on the specific system indicated.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 PRODUCTS

2.01 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal Oil-Sensing Sump Pumps:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Stancor Multi-Option Oil Minder SE or comparable product by one of the following:
      a. Bell & Gossett; a Xylem brand.
      b. Goulds Water Technology; a Xylem brand
      c. Grundfos Pumps Corp
      d. Liberty Pumps
      e. Little Giant Pump Co
      f. Stancor, Inc
      g. Weil Pump Company, Inc
      h. Zoeller Company
   2. Description: Factory-assembled and -tested oil-sensing sump-pump unit built and tested to meet UL 778 standards and shall include thermal overload protection.
      a. The control panel, pump, on/off float, high water alarm float, wiring, J-Box and oil sensor probe shall be factory assembled as a complete assembly, ready to use system and shall be tested, approved and labeled, for the intended purpose as a system, and certified by a nationally recognized independent testing laboratory such as ENTELA.

b. The pump and oil sensor technology control system must comply with ASME A17.1.

3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection. Exposed fasteners shall be AISI Type 316 stainless steel.
5. Impeller: Statically and dynamically balanced, semi-open non-clogging vortex design for clear wastewater handling, and keyed and secured to shaft.
6. Pump Volute: Single piece design with vertical discharge.
7. Pump and Motor Shaft: Stainless steel, with factory-sealed, permanently lubricated, greased ball bearings.
8. Seal: Mechanical.
9. Motor Housing: Type 304 stainless steel.
10. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
    a. Motor Housing Fluid: Air-filled, water-tight.

B. Discharge Connection: 2-inch.

C. Controls:
1. Enclosure: NEMA 250, Type 4X; wall mounted, with wiring terminal strip for field wiring to the junction box in the hoistway.
2. Oil Sensitivity Switch: Field adjustable switch with variable oil sensitivity settings, for indicating oil present, having an adjustable range of 1 to 10, factory set at #5 oil sensitivity and shall be capable of sensing and alarming emulsified oil or solid oil.
3. Motor Overload: Separate over-current relay and field adjustable motor overload having a range of 5 to 15 amps, factory set at 8 amps.
4. Combination manual reset/push to test switch for motor overload with both automatic, manual reset and control diagnostics. The control system must be factory set for automatic overload restart.
5. Main Float Switch: Factory installed, shall automatically start pump on a level increase in the sump pit fluid level. When the water or fluid level drops below the oil sensor probe tip the pump will automatically turn off.
6. High Water Alarm: High water alarm float switch shall act as a redundant pump run (on) float in the event of the main float switch failure.
7. Remediation Provision: Oil-minder by-pass switch mounted on the control panel to allow the control panel to be manually overridden allowing the sump pump to start.
8. Provide a solid state push/hold to test button to perform all pump, alarm, led lights, remote contacts and control diagnostic tests.
9. Junction Box: Provide a NEMA 6P J-Box with a back plate, din rail, screw down terminals and terminal markers.

D. Electrical:
1. Control enclosure shall be provided with power cord and molded ground plug.
2. Wiring from the control panel to the J-Box is to be hard wired with multi-pin connector and manufacturer’s cord in lengths as required. Cord shall be installed in conduit.
3. Wiring from the J-Box to the pump pit (pump cable, probe cable, high liquid alarm cable, and pump “on” float cable) is to be hard wired with manufacturer’s cord (maximum 16 ft.).
4. Wiring shall be in accordance with manufacturer’s written instructions.

E. Motor: The motor housing shall be constructed of #304 stainless steel and mechanical seats shall be housed in a separate oil-filled compartment. Disconnects are provided by the mechanical contractor.
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.02 BUILDING AUTOMATION SYSTEM INTERFACE

A. Building Automation System Interface: Provide auxiliary contacts for interface to the building automation system. Coordinate requirements with BAS provider. Building automation systems are specified in Section 23 09 00 "Building Automation System."

B. Include the following:
   1. On-off status of pump.
   2. Oil detected alarm
   3. High water alarm.
   4. High amperage / motor overload alarm.
   5. Loss of power alarm.
   6. Pump activation alarm.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.02 SUMP PUMP INSTALLATION

A. Install sump pumps according to applicable requirements in HI 1.4.

B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

C. Set submersible sump pumps on elevator pit floor. Make direct connections to sanitary drainage piping.

3.03 CONNECTIONS

A. Piping installation requirements are specified in Division 22 Section "Facility Storm Drainage." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to sump pumps to allow service and maintenance.

C. Connect sanitary drainage piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Refer to Division 22 Section "Facility Storm Drainage."
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for drainage piping.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Disconnect couplings and check motors for proper direction of rotation.
   4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.
   1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.

2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION

SECTION 22 14 63 - RAINWATER COLLECTION SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Rainwater Harvesting System Including the Following:
   1. Rainwater pre-filters.
   2. Storage tanks.
   3. Distribution pumps.
   4. Controls.
   5. Water treatment.

B. Modular Water Management and Storage System Including the Following:
   1. Stacking modules, baseplates, and endplates.
   2. Inspection chambers.
   3. Accessories.

C. Related Requirements:
   1. Section 23 09 00 "Building Automation System" and drawings for rainwater collection system interface to the building automation system.

1.02 RELATED SECTIONS

A. Division 2 - Site Construction.

B. Division 15 - Mechanical.

C. Section 22 14 00 - Facility Storm Drainage.

1.03 REFERENCES

A. International Organization for Standardization (ISO):
   1. ISO 9001 - Quality management systems - Requirements.

B. Underwriters Laboratories (UL):
   1. UL 508 - Standard for Industrial Control Equipment.

1.04 SUBMITTALS

A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

B. Product Data: For system components; include dimensions, capacities, operating characteristics, utility connections, and accessories.

C. Shop Drawings:
   1. For Rainwater Harvesting Systems: Include system layout, components, and accessories.
   2. For Modular Water Storage Systems:
      a. Include engineering, safety factors, specific gravities, atmospheric pressures, project specific loading conditions and capacities, system layout, components, and accessories.
      b. Excavation and base preparation shall be provided in accordance with the shop drawings and Engineer's recommendations.
      c. System shall be sized in accordance with national standards and hydraulic impact.
      d. Unless otherwise shown on shop drawings, sub-grade excavation and preparation shall be executed in accordance with earthwork Drawings and Division 2 specifications.
      e. Unless otherwise shown on shop drawings, sub-surface drainage materials shall be executed in accordance with earthwork Drawings and Division 2 specifications.

D. Closeout Submittals: Operation and maintenance data.
   1. Provide instructions on operation, calibration, troubleshooting, and servicing equipment.
   2. Include layout drawings, parts lists, and component manufacturer's product data.

1.05 SUBMITTALS

A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

B. Product Data:
   1. Manufacturer's data sheets on each product to be used.
   2. Preparation instructions and recommendations.
   3. Storage and handling requirements and recommendations.
   4. Typical installation methods.

C. Verification Samples: Two representative units of each type, size, pattern and color.

D. Shop Drawings: Include details of materials, construction and finish. Include relationship with adjacent construction.

1.06 QUALITY ASSURANCE

A. System Integrator: RainHarvest Systems LLC (800) 654-9283. Russ Jackson.

B. Manufacturer Qualifications:
   1. Minimum 10 years experience in work of this Section.
   2. Successful completion of minimum of 10 previous projects of similar scope and complexity.
   3. Maintain ISO 9001 production facilities including quality management protocols for every production batch.

C. Installer Qualifications:
   1. Successful completion of 3 previous projects of similar scope and complexity.
   2. Maintain factory trained technicians on staff providing field service and warranty work.
   3. Minimum 3 years experience in work of this Section.
   4. For Modular Water Storage Systems:
      a. Installer: Certified by manufacturer and responsible for the following:
         1) Tour, inspect and discuss condition of sub-grade, drainage structures and other preparatory work.
         2) Review required inspections and testing procedures.
         3) Review safety precautions relating to installation.
         4) Use products manufactured or approved by manufacturer.
         5) Follow installation instructions and other contract documents (shop drawings, specifications, approvals, configuration report and manufacturer's recommendations).
         6) Use construction machinery described in manufacturer's installation and maintenance instructions.

D. Excavation Safety: In accordance with OSHA requirements.

1.07 PRE-INSTALLATION CONFERENCE

A. Convene a conference approximately two weeks before scheduled commencement of the Work. Attendees shall include Architect, Contractor and trades involved. Agenda shall include schedule, responsibilities, critical path items and approvals.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver system components until time needed for installation, and after proper protection can be provided.

B. Store and handle in strict compliance with manufacturer's written instructions and recommendations.

C. Protect from damage due to weather, excessive temperature, and construction operations.

D. Leave protective coverings in place until just prior to installation.

E. Store modular water storage system components on smooth surfaces, free from dirt, mud and debris.

F. Handle modular water storage system components with forklifts and manufacturers recommended equipment during transportation and site construction. System components shall be protected from damage during delivery.

1.09 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

1.10 WARRANTY

A. Manufacturer's Warranty: Provide manufacturer's standard limited warranty against defects in materials and workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturer: RainHarvest Systems, LLC, which is located at: 4475 Alicia Lane; Cumming, GA 30028; Toll Free Tel: 800-654-9283; Tel: 770-889-2533; Fax: 770-889-2577 ; Email: request info (rkauk@rainharvest.com); Web: http://www.rainharvest.com
   1. Acceptable Manufacturers for Storage Tanks:
      a. Graf.
      b. RainHarvest Systems.
      c. Atlantis D-Raintank.
      d. RainFlo Corrugated Steel Tanks.
      e. RainFlo FRP Rainwater Storage Tanks.
      f. RainFlo FRP Panel Tanks.
      g. Norwesco.
      h. Chem-Tainer.
   2. Acceptable Manufacturers for Pumps and Pump Skids:
      a. RainHarvest Systems.
      b. Goulds.
      c. RainFlo.
      d. Dab.
   3. Acceptable Manufacturers for Controls and Float Switches:
      a. RainHarvest Systems.
      b. RainFlo.
   4. Acceptable Manufacturers for Rainwater Filters, Storage Tank Accessories, and Purification Kits:
      a. GRAF.
      b. UV Pure.
      c. Viqua.
      d. Pentek.
      e. RainFlo.
      f. Shelco.
      g. Strain-rite.
      h. Amiad.

B. Requests for substitutions will be considered in accordance with provisions of Division 01.

2.02 RAINWATER HARVESTING SYSTEMS

A. Rainwater Harvesting Systems: Components as manufactured by RainHarvest Systems, LLC unless otherwise specified.
   1. System Description: Custom rainwater harvesting system consisting of manufactured components integrated into an automated system. The system shall collect rainwater from the roof and convey rainwater through roof drains, downspouts and conveyance piping, self-cleaning, gravity fed pre-filters. Filtered rainwater will travel through the pre-filter and into a rainwater storage tank. Water will be drawn out of the storage tank and pumped

through a packaged pumping system to the irrigation/plumbing system. The pumping system will be designed to provide water at the desired design point on an on-demand basis.

2. Design Requirements: Filter, store, and distribute harvested rainwater.
3. Water Disinfection Methods: May include sediment filtration, ultraviolet treatment, chlorine injection, carbon filtration, or a combination thereof.
4. Assemble and test purification system in factory prior to shipment to Project site.
5. Hydrostatically test prefabricated pump assembly in factory prior to shipment to Project site.

B. Components:
1. Rainwater Pre-filters: Gravity-fed self-cleaning.
2. Rainwater Pre-Filters:
   a. Graf Model: Optimax-Pro Internal Filter.
3. Rainwater Storage Tanks:
   a. Graf Carat S Tank Below Ground Rainwater Storage System of 1,000 gal.
4. Pump Systems: RainFlo pump system capacity 36 gal per min at 135psi.
   a. RainFlo Packaged Pump System: Manufactured specifically for distribution of rainwater.
   b. Pump shall be of stainless steel construction.
   c. Plumbed to allow for removal without entering tank.
   d. Connected to power supply by power cable and waterproof connections.
5. Pump Control System: Control panel UL 508 listed, and incorporate the following components:
   a. NEMA 3R enclosure.
   b. Single point power connection.
   c. Circuit breaker control power protection.
   d. Individual pump circuit breakers.
   e. Ventilated and fan-cooled enclosure, with positive cabinet pressure.
   f. Variable frequency drives/pump controller will control pumps on an "on-demand" basis via a pressure transducer.
   g. Current limit selector switch to set current limit to match motor SFA.
   h. Alarms indicated by light sequence, audible alarm, or digital readout.
   i. System shall automate switching between rainwater and auxiliary water supply automatically.
   j. System shall display rainwater storage tank level.
6. Rainwater System Control: Continuous water level measurement with automatic switchover to a backup water supply. Controller must activate a 3-way valve based on programmed water levels in the rainwater system controller.
7. Water Treatment Systems: RainHarvest Systems water treatment systems are comprised of multiple components designed to disinfect water for indoor plumbing applications. Under no circumstances should treated water from a rainwater harvesting system be used for potable purposes unless the system has been installed in accordance with and inspected per the local authority having jurisdiction, and the water quality tested to applicable standards.
8. Storage Tank Accessories:
   a. Floating Filter and Hose:
      1) RainHarvest Model: No. 333009.
      2) Description: 2 inch (51 mm) Stainless steel filter housing and mesh fabric, and polyethylene floating ball.
9. Overflow Siphon:
   a. Model: No. 330108.
   b. Description: Polyethylene overflow device with support strut and clamp for 4 inch (102 mm) overflow piping.

C. Accessories:

1. Bulkhead Fittings: Sized to match system inlet, outlet, pump flow rate, vents, and other penetrations.
2. Vent Assembly: PVC rodent-proof cap for tank air and vacuum relief; extend from top of tank to above grade.
3. Waterproof Electrical Connection Box: Located in manway, field installed.

2.03 MODULAR WATER STORAGE SYSTEMS

A. Modular Water Storage Systems:
   1. System Description: Integrated water management solution for stormwater infiltration, retention, detention, rainwater harvesting or firewater tanks. System includes inspection components with site specific configurability without special tools that allows high volume storage and high pressure jetting for cleaning and maintenance.
   2. System Components: From same manufacturer ensuring component compatibility.
   3. Engineering Requirements: Adequate support for project design loads, excavation, subsurface conditions, testing, inspection, and safety requirements Perspecified design criteria.
   4. Assemble and test purification system in factory prior to shipment to Project site.
   5. UV-stabilizer to be protected from sunlight exposure.

B. Modular Water Storage Systems: EcoBloc Inspect Flex as manufactured by RainHarvest Systems, LLC unless otherwise specified.
   1. Engineering Design Criteria for Systems:
      a. Loading Conditions: Verified through compression tests during production.
      b. Long-Term Resistance: Verified in laboratory tests by certified testing laboratory approved by local jurisdiction.
      c. Achieve equal lateral strength in every direction.
      d. General limits of installation shall include safety factors.
      e. Maximal Depth Below Grade: 16 ft and 4.8 inches (5 m).
      f. Tank Height for Pedestrian Loading Applications: 15 ft and 7 inches (4.75 m)
      g. Tank Height for HS-25 Vehicular Applications: 13 ft and 9.4 inches (4.2
      h. m) plus earth covering.
      i. Meet design criteria without additional soil stabilization equipment and without Geogrid.
      j. Sustainable 50 year usable life including safety factors per manufacturer's operating guidelines.
   2. Storage Criteria for Systems:
      a. Capable of storing water products with specific gravity up to 1.1.
      b. Vented to atmospheric pressure.
      c. Capable of storing products identified in manufacturer's limited warranty.
      d. Use and storage of critical biological and chemical ingredients or concentration shall be in accordance with manufacturer's recommendations.
   3. Material Requirements of Systems:
      a. Manufactured with first generation upcycled materials.
      b. Long term properties must be reported by laboratory tests.
   4. System Module Capacities and Dimensions:
      a. Gross Volume: 54.2 US gal (205 L).
      b. Net Volume: 51.5 US gal (195 L).
      c. Nominal Size: 31.5 x 31.5 x 12.6 inches (800 x 800 x 320 mm).
   5. Connections: Allow full drainage and venting of tanks.
      a. Perforated Openings: Up to 8 inches (203 mm), with adaptor plates for pipes up to 20 inches (508 mm).
      b. Manufacturer's EcoBloc Inspect flex base plates and end plates as recommended by manufacturer.
   6. Inspections of Installed Systems:
      a. Allow inspection and high pressure jetting.
      b. Be able to move inspection devices inside structure.

C. Modular Water Storage Systems: EcoBloc Maxx as manufactured by RainHarvest Systems, LLC unless otherwise specified.
   1. Engineering Design Criteria for Systems:
      a. Loading Conditions: Verified through compression tests during production.
      b. Long-Term Resistance: Verified in laboratory tests by certified testing laboratory approved by local jurisdiction.
      c. Achieve equal lateral strength in every direction.
      d. General limits of installation shall include safety factors.
      e. Maximal Depth Below Grade: 16 ft and 4.8 inches (5 m).
      f. Tank Height for Pedestrian Loading Applications: 15 ft and 7 inches (4.75 m).
      g. Tank Height for HS-20 Vehicular Applications: 13 ft and 9.4 inches (4.2
      h. m) plus earth covering.
      i. Meet design criteria without additional soil stabilization equipment and without Geogrid.
      j. Sustainable 50 year usable life including safety factors per manufacturer's operating guidelines.
   2. Storage Criteria for Systems:
      a. Capable of storing water products with specific gravity up to 1.1.
      b. Vented to atmospheric pressure.
      c. Capable of storing products identified in manufacturer's limited warranty.
      d. Use and storage of critical biological and chemical ingredients or concentration shall be in accordance with manufacturer's recommendations.
   3. Material Requirements of Systems:
      a. Manufactured with first generation upcycled materials.
      b. Long term properties must be reported by laboratory tests.
   4. System Module Capacities and Dimensions:
      a. Gross Volume: 59.4 US gal (225 L).
      b. Net Volume: 57.3 US gal (217 L).
      c. Nominal Size: 31.5 x 31.5 x 13.8 inches (800 x 800 x 350 mm).
   5. Connections: Allow full drainage and venting of tanks.
      a. Perforated Openings: Up to 8 inches (203 mm), with adaptor plates for pipes up to 20 inches (508 mm).
      b. Manufacturer's EcoBloc Inspect flex base plates and end plates as recommended by manufacturer.
   6. Inspections of Installed Systems: Compatible with modules that are inspectable.

D. Modular Water Storage Systems: EcoBloc Light as manufactured by RainHarvest Systems, LLC unless otherwise specified.
   1. Engineering Design Criteria for Systems:
      a. Loading Conditions: Verified through compression tests during production.
      b. Long-Term Resistance: Verified in laboratory tests by certified testing laboratory approved by local jurisdiction.
      c. Achieve equal lateral strength in every direction.
      d. General limits of installation shall include safety factors.
      e. Maximal Depth Below Grade: 7 ft and 4.6 inches (2.25 m).
      f. Tank Height for Pedestrian Loading Applications: 7 ft and 4.6 inches (2.25 m).
      g. Tank Height for HS-10 and HS-15 Vehicular Applications: 4 ft and 9.1 inches (1.45 m) plus earth coverings.
      h. Meet design criteria without additional soil stabilization equipment and without Geogrid.
      i. Sustainable 50 year usable life including safety factors per manufacturer's operating guidelines.
   2. Storage Criteria for Systems:
      a. Capable of storing water products with specific gravity up to 1.1.
      b. Vented to atmospheric pressure.
      c. Capable of storing products identified in manufacturer's limited warranty.

d. Use and storage of critical biological and chemical ingredients or concentration shall be in accordance with manufacturer's recommendations.

3. Material Requirements of Systems:
   a. Manufactured with first generation upcycled materials.
   b. Long term properties must be reported by laboratory tests.
4. System Module Capacities and Dimensions:
   a. Gross Volume: 59.4 US gal (225 L).
   b. Net Volume: 57.9 US gal (219 L).
   c. Nominal Size: 31.5 x 31.5 x 13.8 inches (800 x 800 x 350 mm).
5. Connections: Allow full drainage and venting of tanks.
   a. Perforated Openings: Up to 10 inches (254 mm), with adaptor plates for pipes up to 20 inches (508 mm).
   b. Manufacturer's EcoBloc Inspect flex base plates and end plates as recommended by manufacturer.
6. Inspections of Installed Systems: Compatible with modules that are inspectable.

E. Modular Water Storage Systems: Vario 800 Shaft System as manufactured by RainHarvest Systems, LLC unless otherwise specified.
   1. Engineering Design Criteria for Systems:
      a. Loading Conditions: Verified through compression tests during production.
      b. Long-Term Resistance: Verified in laboratory tests by certified testing laboratory approved by local jurisdiction.
      c. Achieve equal lateral strength in every direction.
      d. General limits of installation shall include safety factors.
      e. Maximal Depth Below Grade: 16 ft and 4.8 inches (5 m).
      f. Tank Height for Pedestrian Loading Applications: 15 ft and 7 inches (4.75 m).
      g. Tank Height for HS-25 Vehicular Applications: 13 ft and 9.4 inches (4.2 m) plus earth covering.
      h. Meet design criteria without additional soil stabilization equipment and without Geogrid.
      i. Sustainable 50 year usable life including safety factors per manufacturer's operating guidelines.
      j. Be able to use as inlet, filter, inspection and choke shaft.
      k. Enable free positioning within the EcoBloc system.
      l. Enable easy access with a clear width of 23.6 inches (600 mm).
   2. Storage Criteria for Systems:
      a. Capable of storing water products with specific gravity up to 1.1.
      b. Vented to atmospheric pressure.
      c. Capable of storing products identified in manufacturer's limited warranty.
      d. Use and storage of critical biological and chemical ingredients or concentration shall be in accordance with manufacturer's recommendations.
   3. Material Requirements of Systems: Manufactured with first generation upcycled materials and glass fiber reinforcement.
   4. System Module Capacities and Dimensions:
      a. Gross Volume: 60.7 US gal (230 L).
      b. Gross Volume: 113.5 US gal (420 L).
      c. Nominal Size: 31.5 x 31.5 x 14 inches (800 x 800 x 355 mm).
      d. Nominal Size: 31.5 x 31.5 x 26 inches (800 x 800 x 660 mm).
   5. Connections:
      a. Perforated Openings: Up to 8 inches (203 mm) for inspection access and matching with inspection lanes.
      b. Shaft System Perforated Openings: Up to 8 inches (203 mm).
      c. Shaft System Perforated Openings: Up to 12 inches (304 mm).
      d. Shaft System Perforated Openings: Up to 16 inches (406 mm).
      e. Include manufacturer's Vario 800 flex base/cover set as recommended by the manufacturer.

6. Inspections of Installed Systems: Compatible with modules that are inspectable.

F. Accessories for Modular Water Storage Systems: As manufactured by RainHarvest Systems, LLC unless otherwise specified.
   1. Connectors for System Modules: Requirements.
      a. Interconnect with modular clip system creating a stable, uniform system.
      b. Use connectors only for horizontal connections.
   2. Geotextile:
      a. Specific Weight: 6 oz per sq yd (200 g per sq m). b. CBR: 528.3 to 539.5 lb (2.35 to 2.40 kN).
      b. Opening Width: 0 to 0.004 inch (0 to 100 µm).
      c. Water Permeability: 1268 to 1427 US gal per min (80 to 90 L per sq m).
   3. Adaptor Plates: For pipes up to 20 inches (508 mm).
   4. Venting Ends: 4 inch (100 mm) pipe.
   5. Choke Drains: 4 inch (100 mm) with flow rate of 0.26 to 1.72 US gal per sec (1.0 to 6.5 L per sec).
   6. Choke Drains: 6 inch (152.4 mm) with flow rate of 0.53 to 4.22 US gal per sec (2.0 to 16.1 L per sec).
   7. Geomembrane:
      a. Basis of Design: PE-HD-Geomembrane.
      b. Minimum Thickness: 0.08 inch (2 mm). PART 3 EXECUTION

PART 3 EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Prepare substrates using the methods recommended by the manufacturer for achieving best result for the substrates under project conditions.

B. Do not proceed with installation until substrates have been prepared using the methods recommended by the manufacturer and deviations from manufacturer's recommended tolerances are corrected. Commencement of installation constitutes acceptance of conditions.

C. If preparation is the responsibility of another installer, notify Architect in writing of deviations from manufacturer's recommended installation tolerances and conditions.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions, approved submittals and in proper relationship with adjacent construction.

B. Arrange equipment so that components requiring removal or maintenance are readily accessible without disturbing other components. Arrange for clear passage between components.

C. Connect to utility supplies and equipment.

D. Do not bury components deeper than manufacturer's recommended depth or in a manner that would exceed engineering loads.

E. Do not bury Graf filters deeper than manufacturer's recommended depth unless a vault is installed.

F. Ground components in accordance with component manufacturer's instructions.

G. Install prefilters at time storage tanks are installed.

3.03 FIELD QUALITY CONTROL

A. Field Inspection: Coordinate field inspection in accordance with appropriate sections in Division 01.

B. Manufacturer's Services: Coordinate manufacturer's services in accordance with appropriate sections in Division 01.

C. System Integrators:

1. Installation oversight and technical support.
2. Terminate and test control system wiring and operation of electrical components.
3. Demonstrate proper pump and controls operation.
4. Make adjustments to meet user-defined system performance.
5. Review operation and maintenance procedures with Owner's representative.

3.04 CLEANING AND PROTECTION

A. Clean and protect products in accordance with the manufacturer's recommendations.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 22 35 00 - DOMESTIC WATER HEAT EXCHANGERS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following heat exchangers:
   1. Heating-fluid-in-coil, instantaneous heat exchangers.
   2. Compression tanks.
   3. Heat-exchanger accessories.

B. Related Requirements:
   1. Section 23 09 00 "Building Automation System" and drawings for heat exchanger interface to the building automation system.

1.02 SUBMITTALS

A. Product Data: For each type and size of heat exchanger indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of instantaneous heat exchanger, signed by product manufacturer.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of heat exchangers through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with water.

1.04 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

B. Coordinate heating water piping connections.

1.05 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within a five year1 warranty period. Warranty shall be both standard and extended. Warranties shall be based on final acceptance.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including heat exchanger, storage tank, and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.

PART 2 PRODUCTS

2.01 INSTANTANEOUS HEAT EXCHANGERS

A. Heating-Fluid-in-Coil, Instantaneous Heat Exchangers:
   1. Provide AERCO SmartPlate (SW) heat exchanger or comparable products by one of the following:
      a. Lochinvar.
      b. Bell & Gossett
   2. Description: Packaged assembly of tank, heat-exchanger coils, controls, and specialties for heating domestic water with heating hot water in heat-exchanger coils.
   3. Construction: ASME-code, negligible-capacity, copper-lined, carbon-steel shell with 150-psig minimum working-pressure rating.
      a. Tappings: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
         1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
         2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      b. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
      c. Heat-Exchanger Coils: Copper, helix-wound coils for heating fluid with pressure rating equal to or greater than heating-fluid supply pressure.
      d. Temperature Control: Adjustable thermostat that operates control valve and that is capable of maintaining outlet-water temperature within 4 deg F of setting.
      e. The heater shall be remotely monitored and fully integrated with BAS software via BACnet IP communications protocol.
      f. Safety Control: Automatic, high-temperature-limit cutoff device or system.
      g. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
   4. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, and piping.
   5. Stand: Factory fabricated for floor mounting.
   6. Capacity and Characteristics: See schedule on drawings.

2.02 COMPRESSION TANKS

A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   1. Manufacturers:
      a. AMTROL Inc.
      b. Armstrong Pumps, Inc.
      c. Flexcon Industries.
      d. Honeywell Sparco.
      e. Myers, F. E.; Pentair Pump Group (The).
      f. Smith, A. O.; Aqua-Air Div.
      g. State Industries, Inc.
      h. Taco, Inc.
      i. Watts Regulator Co.
      j. Wessels Co.
   2. Construction:
      a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:
   a. Working-Pressure Rating: 100 psig.
   b. Capacity Acceptable: 10 gal. minimum.

2.03 HEAT-EXCHANGER ACCESSORIES

A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select relief valves with sensing element that extends into heat-exchanger storage tank.

B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than working-pressure rating of heat exchanger.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.04 ELECTRONIC CONTROL SYSTEM

A. Heater shall maintain +/- 2°F max temperature fluctuation from temperature setpoint at 0% to 100 % load at a constant load and +/- 4°F under normal diversified domestic load conditions.

B. The system shall consist of a 3-way electronic control valve, constant speed domestic water circulator pump, control panel enclosure housing a PID temperature controller with digital indication of shell outlet water temperature, heating water inlet and heating water outlet temperatures, digital over-temperature limit switch, and feed-forward and feedback temperature sensors.

C. The controller shall close the control valve in an over-temperature condition. The system shall have the following additional characteristics:
   1. Controller temperature setpoint range between 50°F to 180°F maximum
   2. Configured for 120V/1Phase/60 Hz, 220V/1Phase/60 Hz and 220V/1Phase/50 Hz. Coordinate with electrical.

D. The electronic control valve shall be of equal percentage flow characteristics and have a tight shut-off with low leakage rate of .02% of its Cv value. The valve shall have the following performance characteristics:
   1. 1000:1 turndown.
   2. Magnetic actuator with fail closed design on loss of power.
   3. Time to Full Open Position: 2 seconds
   4. Time to Full Closed Position: 2 seconds

E. The PID temperature controller shall incorporate a feed-forward function and be password protected. The controller shall be capable of remote communications via an add-in board for BACnet IP interoperability with Building Automation Systems (BAS).

F. Controls interface with BACnet shall utilize a communications gateway between the BAS and the temperature controller. Coordinate requirements with BAS provider. The communications gateway shall be comprised of a microprocessor-based control to communicate with the temperature controller. Non-volatile backup of all point mappings and programs shall be internally provided as standard. Provide point data in BACnet IP format to Division 25.

G. The following information shall be accessible locally at the controller or remotely via the communications port:
   1. Setpoint. Shall be capable of being changed remotely.
   2. Outlet temperature
   3. Over temperature alarm
   4. Control output signal to valve.

2.05 SOURCE QUALITY CONTROL

A. Test and inspect heat-exchanger storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial heat-exchanger storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 EXECUTION

3.01 HEAT-EXCHANGER INSTALLATION

A. Install heat exchangers on concrete bases.

B. Install heat exchangers level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Anchor heat exchangers to substrate.

D. Install temperature and pressure relief valves in top portion of storage tank shells of heat exchangers with domestic water storage. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install combination temperature and pressure relief valves in water piping for heat exchangers without storage. Extend relief-valve outlet, with drain piping same as water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for heat exchangers that do not have tank drains.

G. Install thermometer on each heat-exchanger domestic-water inlet and outlet piping, and install thermometer on each heat-exchanger heating-fluid inlet and outlet piping. thermometers.

H. Install pressure gages on heat-exchanger heating-fluid piping.

I. Fill heat exchangers with water.

J. Charge compression tanks with air.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to heat exchangers to allow service and maintenance. Arrange piping for easy removal of heat exchangers.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace heat exchangers that do not pass tests and inspections and retest as specified above.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION

SECTION 22 40 00 - PLUMBING FIXTURES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Lavatory Faucets
   2. Sink Faucets
   3. Flush meters
   4. Toilet Seats
   5. Fixture Supports
   6. Dishwater Air Gap Fittings
   7. Water Closets
   8. Urinals
   9. Lavatories
   10. Sinks
   11. Laboratory Sinks
   12. Mop Basins
   13. Emergency Eye Wash
   14. Soap Dispensers
   15. Utility Sinks.
   16. Refer to Section 12 35 53 for Lab sinks, emergency showers, and emergency eye wash stations.

1.02 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.03 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in the North Carolina Building Code for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
   2. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
   3. Vitreous-China Fixtures: ASME A112.19.2M.
   4. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   4. Faucets: ASME A112.18.1.
   5. Hose-Connection Vacuum Breakers: ASSE 1011.
   6. Hose-Coupling Threads: ASME B1.20.7.
   7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   8. NSF Potable-Water Materials: NSF 61.
   9. Pipe Threads: ASME B1.20.1.
   10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   11. Supply Fittings: ASME A112.18.1.
   12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1.
   3. Dishwasher Air-Gap Fittings: ASSE 1021.
   4. Brass Waste Fittings: ASME A112.18.2.
   5. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Dishwasher Air-Gap Fittings: ASSE 1021.
   2. Flexible Water Connectors: ASME A112.18.6.
   3. Floor Drains: ASME A112.6.3.
   4. Hose-Coupling Threads: ASME B1.20.7.
   5. Off-Floor Fixture Supports: ASME A112.6.1M.
   6. Pipe Threads: ASME B1.20.1.

7. Plastic Toilet Seats: ANSI Z124.5.
8. Supply and Drain Protective Shielding Guards: ICC A117.1.

K. For all sensor faucets, provide integral thermostatic mixing valves.

L. Provide sinks with traps.

M. Contractor shall verify countertop dimensions with all sinks and faucets prior to submittals. Note in submittals any dimensions changes due to counter depths.

N. All flush valves for toilets and urinals shall be rated for reclaim water use.

1.05 WARRANTY

A. Warranty Period for Commercial Applications: Three year(s) from date of Final Acceptance.

1.06 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.

1.07 FIXTURE CONNECTIONS

A. Provide all plumbing connections required by fixtures which are provided on this project. Provide valved water supplies, waste and vent lines, and, unless noted otherwise, make final connections after fixtures are in place.

PART 2 PRODUCTS

2.01 LAVATORY FAUCETS

A. Lavatory Faucets:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
a. Chicago Faucets.
b. Zurn
c. Sloan
2. Description: Single-control mixing valve. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
a. Body Material: Commercial, solid brass.
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 0.5 gpm.
d. Mounting: Deck, exposed.
e. Valve Handle(s): Not applicable.
f. Spout: Rigid type.
g. Spout Outlet: Aerator.
h. Operation: Sensor.
i. Drain: Grid.
j. Tempering Device: Provide either with device or separate above ceiling.

2.02 SINK FAUCETS

A. Utility Sink Faucets:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:

a. Powers; a Watts Industries Co.
b. Symmons Industries, Inc.
c. T & S Brass and Bronze Works, Inc
d. Chicago.

2. Description: Deck mounted 8” gooseneck with 4” wrist blades.
a. Body Material: Solid brass.
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 1.5 gpm, unless otherwise indicated.
d. Operation: manual.
e. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
f. Supply Connections: NPS 1/2.

B. Mop Sink Faucets:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
a. Delta Faucet Company.
b. Kohler Co.
c. Moen, Inc
d. Chicago.
2. Description: Wall mounted concealed service sink hot and cold water faucet with stops in shanks, vacuum breaker, hose-thread outlet and pail hook.
a. Body Material: Commercial, solid brass.
b. Finish: Rough brass.
c. Maximum Flow Rate: 2.5 gpm, unless otherwise indicated.
d. Mixing Valve: Single control for each (hot and cold).
e. Backflow Protection Device for Hose Outlet: Required.
f. Handle(s): Knob.
g. Inlet(s): NPS 1/2 female shank.
h. Spout Type: Rigid, solid brass.
i. Spout Outlet: Hose thread.
j. Vacuum Breaker: Required.
k. Operation: Compression, manual.
l. Drain: Grid

C. Breakroom Faucets:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
a. Powers; a Watts Industries Co.
b. Symmons Industries, Inc.
c. T & S Brass and Bronze Works, Inc
d. Chicago
e. Elkay.
2. Description: Deck mounted mixing gooseneck with pulldown spray, single lever handle.
a. Body Material: Commercial, solid brass.
b. Finish: brushed plate.
c. Maximum Flow Rate: 0.5 gpm.
d. Mounting: Deck, exposed.
e. Valve Handle(s): single lever.
f. Spout: pulldown type.
g. Spout Outlet: Aerator.
h. Operation: manual.

2.03 FLUSHOMETERS

A. Flushometers for urinals:

1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
   a. American Standard
   b. Sloan
   c. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Flushometer for urinal type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts. Rated for reclaim water use.
   a. Internal Design: piston operation.
   b. Style: Exposed.
   c. Inlet Size: NPS 3/4 and NPS 1.
   d. Trip Mechanism: hardwired with automatic infrared sensor.
   e. Consumption: 0.125 gal/flush.

B. Flushometers for Water Closets:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
   a. American Standard
   b. Sloan
   c. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Flushometer for water closet type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts. Rated for reclaim water use.
   a. Internal Design: Diaphragm operation.
   b. Style: Exposed.
   c. Inlet Size: NPS 3/4 and NPS 1.
   d. Trip Mechanism: dual flush hardwired valve with flush button.
   e. Consumption: 1.1/1.6 gal/flush.

2.04 TOILET SEATS

A. Toilet Seats:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bemis Manufacturing Company.
   b. Church Seats.
   c. Olsonite Corp.
2. Description: Toilet seat for water-closet-type fixture with Sta-tite fastening hardware system.
   a. Material: Molded, solid plastic.
   b. Configuration: Open front without cover.
   c. Size: Elongated.
   d. Hinge Type: SC, self-sustaining, check.
   e. Class: Heavy-duty commercial.
   f. Color: White.

2.05 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co
4. Kohler
5. Sloan.

B. Water-Closet Supports:
   1. Description: Combination carrier designed for accessible and standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:
   1. Description: Type II, urinal carrier with hanger and bearing plates for wall-mounting, urinal-type fixture. Include steel uprights with feet.
   2. Accessible-Fixture Support: Include rectangular steel uprights.

2.06 DISHWASHER AIR-GAP FITTINGS

A. Dishwasher Air-Gap Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brass Craft Mfg. Co.; a Subsidiary of Masco Corporation.
      b. Geberit Manufacturing, Inc.
      c. Sioux Chief Manufacturing Company, Inc.
      d. Watts Brass & Tubular; a division of Watts Regulator Co.
   2. Description: Fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body, chrome-plated brass cover; and capacity of at least 5 gpm; and inlet pressure of at least 5 psig at a temperature of at least 140 deg F. Include 5/8-inch- ID inlet and 7/8-inch- ID outlet hose connections.
   3. Hoses: Rubber and suitable for temperature of at least 140 deg F.
      a. Inlet Hose: 5/8-inch ID and 48 inches long.
      b. Outlet Hose: 7/8-inch ID and 48 inches long.

2.07 WATER CLOSETS

A. Water Closets:
   1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
      a. Zurn
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Eljer
      d. Kohler.
   2. Description: Accessible wall mounting and Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
      a. Style: Dual Flushometer valve.
         1) Bowl Type: Elongated with siphon-jet design.
         2) Trip Mechanism: Dual Flush.
         3) Color: White.
      b. Supply: 1-inch chrome-plated brass or copper with loose-key stop.
      c. Flushometer: As specified.
      d. Toilet Seat: As specified.
      e. Fixture Support: As specified.

2.08 URINALS

A. Urinals:
   1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
      a. American Standard Companies, Inc.
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Eljer
      d. Sloan.

2. Description: Accessible, wall and Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
    a. Type: Siphon jet.
    b. Strainer or Trapway: Integral cast strainer with integral trap.
    c. Design Consumption: 0.125 gal./flush.
    d. Color: White.
    e. Supply Spud Size: NPS 3/4.
    f. Outlet Size: NPS 1-1/2.

2.09 LAVATORIES

A. Lavatories:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
    a. Crane Plumbing, L.L.C./Fiat Products.
    b. Eljer
    c. Corian
    d. American Standard
    e. Sloan
2. Description: integral rectangular, undermount, solid surface vanity. Nonporous surface, acrylic-modified polyester material with integral overflow.
    a. Size: 19-1/2” by 14-1/4” inches oval. Inside bowl dimensions 18” x 12-3/4” x 5”
    b. Color: White.
    c. Drain Piping: NPS 1-1/4 by NPS 1-1/2 chrome-plated, cast-brass P-trap; 0.045-inch-thick tubular brass waste to wall; and wall escutcheon near back of bowl.

2.10 SINKS

A. Hand Sinks
1. Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
    a. Dayton Products, Inc.
    b. Just Manufacturing Company
    c. American Standard.
2. Description: One-bowl, wall hung vitreous china rear overflow, soap depression faucet ledge.
    a. Overall Dimensions: 18-1/2” x 17”
    b. Bowl:
        1) Dimensions: 14-1/4” x 10-3/4” x 6”
        2) Drain: 3-1/4” trap.

B. Single Bowl Sink:
1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
    a. Dayton Products, Inc.
    b. Just Manufacturing Company
    c. Elkay.
2. Description: double basin, top mount 22 gauge type 304 stainless-steel sink. Mechanical or Plumbing contractor shall verify sink dimensions with counter top dimensions prior to purchase.
    a. Overall Dimensions: 15” x 19”
    b. Bowl Dimensions 1: 10 “x 14”x 6-1/4” deep
    c. Bowl Dimension 2: 10”x14”x6-1/4”
    d. Supplies: NPS 1/2 chrome-plated copper with stops.
    e. Drain: 3-1/2-inch crumb cup
    f. Drain Piping: NPS 1-1/2 chrome-plated, cast-brass P-trap; 0.045-inch- thick tubular brass waste to wall; and wall escutcheon.

2.11 MOP BASINS

A. Service Basins:
   1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
      a. Acorn Engineering Company.
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Florestone Products Co., Inc.
      d. Mustee, E. L. & Sons, Inc
      e. Fiat.
   2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard.
      a. Shape: Square.
      b. Size: 36 by 36 inches.
      c. Height: 12 inches with dropped front.
      d. Tiling Flange: On three sides.
      e. Rim Guard: On all top surfaces (stainless-steel).
      f. Faucet: Sink as specified.
      g. Drain: Grid with NPS 3 outlet.
      h. Splash Guard: Fiberglass.

2.12 UTILITY SINK

A. Service Basins:
   1. Manufacturers: Subject to compliance with requirements, equal products by one of the following in accordance with plumbing fixture schedule:
      a. Acorn Engineering Company.
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Florestone Products Co., Inc.
      d. Mustee, E. L. & Sons, Inc
      e. Fiat.
   2. Description: single bowl floor mount utility sink, 17 gallon.
      a. Shape: Square.
      b. Size: 23” x 21.5” x 34.75” inches.
      c. Faucet: Sink as specified.
      d. Drain: Grid with NPS 3 outlet.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. All exposed metal parts of all fixtures, including all trim and fittings shall be brass.

C. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
   4. No wood grounds, wood plugs, or expansion bolts shall be permitted for fixture support.

D. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

E. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

F. Install wall-mounting fixtures with tubular waste piping attached to supports.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation. All nipples shall be chrome plated brass.
   1. Exception: Use ball if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install toilet seats on water closets.

N. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

P. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

Q. Install shower flow-control fittings with specified maximum flow rates in shower arms.

R. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

S. 1Install vacuum back flow prevention device on Owner provided refrigerator water connections.

T. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

U. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

V. All faucet handles, where possible, shall have color coded “indexes” identifying the service used.

W. Water supplies for handicapped lavatories and sinks shall be insulated. Waste lines for handicapped lavatories and sinks shall be offset and insulated.

X. Water supplies for handicapped water closets shall be roughed-in for flush valve handle to be operated from the accessible side of the water closet. Contractor shall coordinate and provide flush handle on the accessible side of all tank type handicapped water closets.

Y. Provide backflow devices on all faucets and fittings requiring backflow prevention. Devices may be inline type when not provided integral with the faucet.

Z. All serrated or slip hose connection spout outlets shall have Allen wrench operated volume controls to control splashing of water as it hits sink bottom.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 11FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.05 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.06 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.07 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 22 47 00 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 GENERAL

1.01 DEFINITIONS

A. Cast Polymer: Dense, cast-filled-polymer plastic.

B. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

C. Fitting: Device that controls flow of water into or out of fixture.

D. Fixture: Drinking fountain or water cooler unless one is specifically indicated.

E. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.

F. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.02 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

D. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.

E. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

1.04 WARRANTIES

A. 5 year limited warranty on the refrigeration system of the unit. Electrical components and water system are warranted for 12 months from date of final acceptance.

PART 2 PRODUCTS

2.01 ELECTRICAL WATER COOLERS

A. Electric Water Coolers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay LVRCTL8WSK or a comparable product:
2. Description: Accessible, No Lead, Two Level, Filtered, Wall Mount, Barrier Free with Bottle Filling Station.

a. Architectural fountains with integral bottle filling station. LVRCTL8WSK shall deliver 8 GPH of 50°F drinking water, based on 80 F inlet water and 90 F ambient, per ASHRAE 18 testing. Features shall include visual filter monitor, filtered, green ticker, laminar flow, real drain, vandal-resistant. Furnished with vandal-resistant bubbler. Electronic bottle filler button with mechanical front bubbler button activation. Product shall be wall mount (on-wall), for indoor applications, serving 2 stations. Unit shall be certified to UL399 and CAN/CSA 22.2 No. 120. Unit shall be lead-free design which is NSF/ANSI 61 & 372 (lead free) and meets Federal and State low-lead requirements.
b. Mechanically-activated bubbler continues to supply water in event of service disruptions. Visual filter monitor with LED filter status indicator for when filter change is necessary. Filter is certified to NDF 42 and 53 for lead, particulate, chlorine, taste and odor reduction. 3,000 gallon capacity. Green ticker informs user of number of 20 ounce plastic water bottles saved from waste. Laminar flow provides clean fill with minimal splash. Real drain system eliminates standing water. Vandal-resistant, bubblers are one-piece, chrome plated with integral hood guard design to prevent contamination from other users, airborne deposits and tampering. Hermetically-sealed, reciprocating type, single phase compressor, sealed in lifetime lubrication. Fan-cooled, copper tube with aluminum fins condenser with permanently lubricated fan motor. Cooling unit of combination tube-tank type with continuous copper tubing that is fully insulated with EPS foam that meets UL requirements for self-extinguishing material. Refrigerant R-143a is controlled by accurately calibrated capillary tube. Temperature control is easily accessible enclosed adjustable thermostat is factory preset which requires no adjustment other than for altitude requirements.
c. Include water cooler LVRCTL8WSK, bottle filler LVRCWS and filter.
d. Include 51300C-WaterSentry Plus Replacement Filter (Bottle Fillers), 98324C-Cane apron for HAC, HVR, EMABF & VRC Models (Stainless), 36292C-Accessory-Power Block and WSF6000R-2PK-WaterSentry Fresh 6000 CTO Filter-Replacement (2 pack).

2.02 FIXTURE SUPPORTS

A. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
   1. Type I: Hanger-type carrier with two vertical uprights.
   2. Type II: Bilevel, hanger-type carrier with three vertical uprights.
   3. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.
B. Examine walls and floors for suitable conditions where fixtures are to be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
B. Use mounting frames for recessed water coolers, unless otherwise indicated.
C. Set freestanding and pedestal drinking fountains on floor.
D. Set remote water coolers on floor, unless otherwise indicated.

E. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.03 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.

B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.

C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system unless provided by manufacturer.

F. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.04 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.05 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
   1. Remove and replace malfunctioning units and retest as specified above.
   2. Report test results in writing.

3.06 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.07 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

SECTION 22 61 13 - COMPRESSED-AIR PIPING FOR LABORATORY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "compressed air" operating at 100 psig. Includes both Laboratory and Shop compressed air.
   2. Compressed-air piping and specialties for nonmedical laboratory facilities, designated “compressed dry air” operating at 100 psig. Includes both Laboratory and Shop compressed air.

1.02 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Compressed-air tubes and fittings.
   2. Compressed-air valves and valve boxes.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Piping Material Certification: Signed by Installer certifying that medical compressed-air piping materials comply with NFPA 99 requirements.

D. Qualification Data: For Installer and testing agency.

E. Brazing certificates.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section "Specialty Gas Piping for Laboratory Facilities."

B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance:
   1. Comply with ASME B31.9, "Building Services Piping," for laboratory compressed-air piping operating at 150 psig or less.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type K, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

B. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   2. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

2.02 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

2.03 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Ball Valves: MSS SP-110, 3-piece body, brass, or bronze.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amico Corporation.
      b. Conbraco Industries, Inc.
      c. NIBCO INC.
   2. Pressure Rating: 300 psig minimum.
   3. Ball: Full-port, chrome-plated brass.
   4. Seats: PTFE or TFE.
   5. Handle: Lever type with locking device.
   6. Stem: Blowout proof with PTFE or TFE seal.
   7. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

C. Check Valves: In-line pattern, bronze.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amico Corporation.
      b. Conbraco Industries, Inc.
      c. NIBCO INC.
   2. Pressure Rating: 300 psig minimum.
   3. Operation: Spring loaded.
   4. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

2.04 FLEXIBLE PIPE CONNECTORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Hyspan Precision Products, Inc.
   4. Mercer Rubber Co.
   5. Metraflex, Inc.
   6. Proco Products, Inc.
   7. Unaflex.
   8. Universal Metal Hose; a Hyspan Co.

C. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   1. Working-Pressure Rating: 200 psig minimum.
   2. End Connections: Threaded copper pipe or plain-end copper tube.

2.05 RETRACTABLE AIR HOSE REEL ASSEMBLIES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Reelcraft Model 4435m OLP or comparable product by one of the following:
   1. Coxreels.
   2. Lincoln.

B. Single-Low Pressure-Spring Retractable-Air Hose Reel:
   1. Hose-Rack Material: Heavy Duty Steel.
   2. Body Material: Heavy Duty Steel.
   3. Body Finish: Powder coated finish, color by Architect.
   4. Mounting: Wall, with reinforcement.
   5. Supply Fitting: NPS 1/2 ball valve and inlet hose.
   6. Hose: Manufacturer's standard, for compressed air, rated at 300 psi; 35 feetlong, NPS ¼ ID, NPS ½ OD.
   7. Nozzle: Elongated bronze.
   8. Spring: Non-corrosive stainless-steel spring with zinc plated rachet.

2.06 NITROGEN

A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

2.07 ZONE-VALVE BOX ASSEMBLIES: BOX WITH VALVE AND GLASS DOOR

A. Steel Zone-Valve Box with Aluminum Cover.

B. Description: Formed-16 gauge stainless steel box with cover, anchors for recessed mounting, holes with grommets in box sides for piping extension protection, and of size for single or multiple valves in sizes required to permit manual operation of valves.
   1. Description: Formed-stainless steel box with cover, anchors for recessed mounting, holes with grommets in box for piping extension protection, and of size for single or multiple valves in sizes required to permit manual operation of valves.
   2. Cover Plate: Stainless steel with frangible or removable windows.
   3. Valve-Box Windows: Clear plastic with labeling that includes rooms served, in accordance with NFPA 99.

2.08 PRESSURE REGULATORS

A. Aluminum body with nonrising adjustment knob.

B. Spring-loaded, diaphragm-operated, relieving type.

C. Manual pressure-setting adjustment.

D. Rated for 300-psig minimum inlet pressure.

E. Maximum flow 450 CFM

F. Capable of controlling delivered air pressure from 5 to 125 psi.

G. 1 ½” NPT inlet and outlet.

PART 3 EXECUTION

3.01 PIPING APPLICATIONS

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Compressed Air Piping: Use the following piping materials for each size range:
   1. NPS 4 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

C. Compressed Dry Air Piping: Use the following piping materials for each size range:
   1. NPS 4 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

D. Drain Piping: Use the following piping materials:
   1. Copper water tube, cast- or wrought-copper fittings, and soldered joints.

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Comply with ASSE Standard #6010 for installation of compressed-air piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install air and drain piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.

I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.

P. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.03 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.

C. Install pressure regulators on compressed-air piping where reduced pressure is required.

D. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.

E. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.04 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

3.05 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4: 60 inches with 3/8-inch rod.
   2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
   3. NPS 3/4: 84 inches with 3/8-inch rod.
   4. NPS 1: 96 inches with 3/8-inch rod.
   5. NPS 1-1/4: 108 inches with 3/8-inch rod.
   6. NPS 1-1/2: 10 feet with 3/8-inch rod.
   7. NPS 2: 11 feet with 3/8-inch rod.
   8. NPS 2-1/2: 13 feet with 1/2-inch rod.
   9. NPS 3: 14 feet with 1/2-inch rod.
   10. NPS 3-1/2: 15 feet with 1/2-inch rod.
   11. NPS 4: 16 feet with 1/2-inch rod.

J. Install supports for vertical copper tubing every 10 feet.

3.06 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.07 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN NONMEDICAL LABORATORY FACILITIES

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.

B. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.

C. Tests and Inspections:
   1. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect filters and pressure regulators for proper operation.

3.08 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.09 PIPING SCHEDULE

A. Flanges may be used where connection to flanged equipment is required.

B. Compressed Air Piping:
   1. Compressed Air: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
   2. Compressed Dry Air: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.10 VALVE SCHEDULE

A. Shutoff Valves: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

3.11 DEMONSTRATION

A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain compressed air equipment and associated piping.

END OF SECTION

SECTION 22 61 19 - COMPRESSED-AIR EQUIPMENT FOR LABORATORY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Rotary-screw air compressors.
   2. Inlet-air filters.

1.02 DEFINITIONS

A. Actual Air: Air delivered at air-compressor outlet. Flow rate is compressed air delivered and measured in acfm.

B. Laboratory Air Equipment: Compressed-air equipment and accessories for nonmedical laboratory facilities.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design compressed-air equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   1. Wiring Diagrams: For power, signal, and control wiring.

B. Qualification Data: For qualified Installer and testing agency.

C. Field quality-control reports.

D. Operation and Maintenance Data: For compressed-air equipment to include in operation and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Laboratory Air System Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

1.06 COORDINATION

A. Coordinate sizes and locations of concrete bases with equipment provided.

1.07 SHIPMENT AND DELIVERY PREPARATION

A. The compressor shall be packaged on a wooden skid and fully enclosed with a wooden enclosure.

1.08 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Air-Compressor, Inlet-Air Filter Elements: Provide two units.

PART 2 PRODUCTS

2.01 ROTARY-SCREW AIR COMPRESSOR

A. Basis-of-Design Product: Subject to compliance with requirements, provide Atlas Copco model GA11VSD+ or comparable product by one of the following:
   1. CompAir, Ltd.
   2. Gardner Denver, Inc.
   3. Ingersoll-Rand.

B. Description: Factory-assembled, -packaged, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

C. General:
   1. Compressor shall be capable of producing and delivering 100% of the required air demand as specified at standard operating conditions.
   2. Compressor shall be designed and supplied as a complete package with all necessary equipment, including but not limited to the following components: inlet filter, air compression element, drive motor, aftercooler with integral moisture separator, oil cooler, cooling fan, variable-frequency drive, microprocessor regulation and control system.
      a. All components shall be mounted on a common solid base frame and fully enclosed with a sound attenuating enclosure.
   3. Compressor package shall be rated to operate in ambient conditions from 32°F to 115°F.
   4. Compressor shall be able to operate at any speed in between its minimum and maximum speed.
   5. Compressor must not idle, unload or blow-down the sump when the demand decreases below the minimum flow of the compressor. The compressor shall stop and it shall remain pressurized so that it can immediately come back on-line when required.
   6. The manufacturer shall be certified under ISO 9001 / 9002 quality standards and ISO 14001 environmental standards.

D. Enclosure:
   1. Compressor shall be enclosed in a steel sound attenuating canopy with removable panels.
   2. The sound attenuating material shall be flame retardant polyurethane foam.

E. Noise Levels
   1. The compressor package shall not exceed 63 dB(A) when measured in the free field conditions at one meter in accordance with the CAGI-Pneurop Test Code.

F. Compressor Element
   1. The compression profile shall be of the asymmetric profile design with four lobes on the male rotor and six lobes on the female rotor.
   2. The male and female rotors shall have the same diameter.
   3. The element housing shall be of cast iron construction.
   4. Compressor Element
   5. The compression profile shall be of the asymmetric profile design with four lobes on the male rotor and six lobes on the female rotor.
   6. The male and female rotors shall have the same diameter.
   7. The element housing shall be of cast iron construction.

G. Drive Motor
   1. The drive motor must be oil-cooled, inverter duty, DC permanent magnet type with IE4 super premium efficiency motor.
   2. The motor shall conform with NEMA MG 1 for 60Hz applications and IEC 34-1, EN60034-1 for 50 Hz applications.

3. The inboard motor bearing shall be lubricated by the compressor lubricant and the rear motor bearings shall be greased for the life of the motor.
4. The complete motor shall be 100% maintenance-free.
5. Approved manufacturers include:
    a. Siemens
    b. Lincoln
    c. ABB
    d. TECO Westinghouse
    e. Reliance
    f. Leroy Somer
    g. Toshiba
    h. Baldor

H. Drive Arrangement
1. The drive arrangement shall be a direct-driven design.
2. The drive system shall be fully enclosed to protect against dirt and dust intrusion.
3. The drive gear shall be directly mounted on the end of the motor shaft eliminating the need for a coupling.
4. The driven gear shall be helically cut to exert compensating thrust on the rotors to offset axial loads generated during compression.

I. Cooling System
1. The compressor package shall be fitted with an aluminum, air-cooled, oil cooler and aftercooler.
2. The cooling system shall include an axial fan driven by a Totally Enclosed Fan Cooled (TEFC) motor.

J. Moisture Separator
1. The compressor shall be equipped with a labyrinth style moisture separator integrated in the discharge side of the after-cooler.

K. Electronic Water Drain
1. The compressor will have a zero loss electronic water drain plumbed to the aftercooler.
2. These drains shall discharge no compressed air during removal of the condensate.
3. The zero loss drains shall be monitored by the microprocessor controller.
4. A manual condensate drain shall also be included.

L. Inlet Air Filter
1. Combination inlet-air filter-silencer for each air compressor.
2. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
3. Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.
4. The filter shall be equipped with a differential pressure indicator for monitoring by the control system.
5. The service interval of the filter must be at least 4,000 hours.

M. Oil System
1. The oil system shall include an ASME approved air/oil separator with oil level indicator. The service interval of the separator element must be at least 8,000 hours.
2. The oil filter shall be a spin-on type with an integrated bypass valve. The oil filter element will have a 12 micron beta 75 rating and the service interval must be at least 8,000 hours.
3. The oil temperature shall be regulated by means of a thermostatic bypass valve. Oil circulation is achieved through differential pressure.
4. The oil must be synthetic and rated for a change interval of 8,000 hours.
5. The oil system must use O-rings to provide a positive seal. No gaskets can be used.

N. Electric Panel

1. The control panel must be designed to NEMA 3R or IP 54 standards.
2. The panel must include a cooling fan and vent to force ambient air through the panel.
3. The variable speed drive of the main motor must be IP 5X or equivalent.
4. The compressor package shall have adequate filtration provisions to comply with or exceed EMC directives 8/C9/EEC and 89/336/EEC.
5. An RFI filter shall be integrated into the VSD package to significantly reduce harmonic distortion of the VSD.
6. A line reactor shall be integrated into the VSD package to eliminate harmonic distortion of the power supply from the converter. The impedance of the line reactor shall be no more than 3% and no less than 2%
7. The VSD compressor package shall be immune to damage induced by VSD current pulses for optimum performance and service lifetime.
8. Motor bearings shall be insulated for protection against EDM craters induced by VSD current pulses, ensuring maximum bearing lifetime.
9. Motor and compressor couplings shall be isolated from each other with no metal contact between them. A flexible drive coupling with rubber buffers shall be used.
10. High frequency bonding straps shall be installed between the earth level of the inverter and the motor to eliminate induced currents on the motor frame.
11. The printed circuit boards of the variable speed drive shall be epoxy coated to prevent damage caused by moisture or aggressive environments.

O. Regulating and Control System
1. The compressor shall have a regulating system which is of the variable-speed design, controlled by an air compressor discharge pressure sensor which senses the pressure variations at the compressor discharge and adjusts the speed of the compressor to maintain a stable discharge pressure.
2. The full variable-speed regulation shall be combined with start / stop regulation to automatically stop the compressor as required during low demand periods without idling or unloading the compressor.
3. The compressor shall be equipped with an onboard microprocessor controller which will control, monitor and protect the operation and condition of the air compressor.
4. The controller shall have a 3.5” color display.
5. The controller shall allow programming of two pressure set points.
6. Time based start / stop and changeover of the pressure set point shall be programmable.
7. The controller must be capable of automatically restarting the compressor in the event of a voltage failure.
8. The controller must be capable of graphing any of the measured temperature or pressure inputs on the display. The time frame of the graph shall be adjustable from 4 minutes to 10 days.
9. The compressor shall be able to be controlled locally, remotely or via a local area network.
10. The controller must be equipped with auxiliary contacts for external indication of automatic or manual load control, general warning and general shutdown conditions.
11. The controller must be capable of providing remote monitoring by a PC through the local Ethernet system via an Ethernet port on the controller.
12. The controller must be capable of providing remote monitoring via a iPhone, iPad, or Android phone or tablet.
13. The controller shall monitor the hours of operation and output a message on the display to notify the operator to provide preventative maintenance in accordance with the factory approved service plan.
14. The control system shall have the capability to monitor the following items:
    a. Discharge air pressure
    b. Element outlet temperature
    c. Ambient temperature
    d. Compressor status

e. Motor overload status
f. Running hours
g. Loaded hours
h. Regulator hours

15. Compressor protective functions shall include:
    a. Emergency stop
    b. Element outlet temperature
    c. Service warnings
    d. Drive and cooling fan motor overload

P. Performance Requirements:
1. Compressed-Air Service: Laboratory air.
2. Air Compressor(s): Two.
3. System Capacity: 68.7 acfm delivered.
4. Discharge-Air Pressure: 102 psig.
5. Mounting: Floor mounted, solid base frame.
6. Motor (Each Air Compressor):
    a. Horsepower: 15.
    b. Speed: Variable.
7. Unit Electrical Characteristics:
    a. Volts: 480.
    b. Phase(s): Three.
    c. Hertz: 60 Hz.

Q. Building Automation System Interface:
1. Provide interface to the building automation system through a gateway and converter. Coordinate requirements with BAS provider. Building automation system is specified in Section 23 09 00 "Building Automation System."
2. All monitoring and control features, which are available at the Control Panel, shall also be available remotely through the building automation system.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean compressed-air equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory air applications, according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."

3.02 COMPRESSED-AIR EQUIPMENT INSTALLATION

A. General Requirements for Compressed-Air Equipment Installation:
1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.
5. Install the following devices on compressed-air equipment:
    a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
    b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
    c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

B. Nonmedical Laboratory Compressed-Air Equipment Installation:
   1. Install compressed-air equipment, except wall-mounting equipment, on concrete bases. Install units anchored to substrate in locations indicated. Maintain manufacturers' recommended clearances. Orient equipment so controls and devices are accessible for servicing.
      a. Anchor equipment to concrete bases according to manufacturer's written instructions.
         1) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
         2) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
         3) Install anchor bolts to elevations required for proper attachment to supported equipment.
      b. Vibration Isolation: Mount equipment on a vibration isolation equipment base as specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

3.03 CONNECTIONS

A. Comply with requirements for water-supply piping specified in Division 22 Section "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for drain piping specified in Division 22 Section "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for compressed-air piping specified in Division 22 Section "Compressed-Air Piping for Laboratory Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Install piping adjacent to equipment to allow service and maintenance.

E. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.

F. Connect water supply to compressed-air equipment that requires water. Include backflow preventer. Backflow preventers are specified in Division 22 Section "Domestic Water Piping Specialties."

3.04 IDENTIFICATION

A. Identify nonmedical laboratory compressed-air equipment system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

B. Identify medical compressed-air equipment system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment." and comply with NFPA 99.

3.05 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check for lubricating oil in lubricated-type equipment.
   3. Check belt drives for proper tension.
   4. Verify that air-compressor inlet filters and piping are clear.
   5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
   6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure but not higher than rating of system components.
   7. Check for proper seismic restraints.
   8. Drain receiver tanks.

9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
10. Test and adjust controls and safeties.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors and compressed-air dryers.

END OF SECTION

SECTION 22 63 13 – SPECIALTY GAS PIPING FOR LABORATORY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Carbon dioxide piping and specialties designated "carbon dioxide" operating at 50 to 55 psig.
   2. Oxygen piping and specialties designated "oxygen" operating at 50 to 55 psig.
   3. Nitrogen piping and specialties designated "nitrogen" operating at 50 to 55 psig.

B. Owner-Furnished Material:
   1. Specialty gas cylinders.

1.02 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

C. Specialty Gas: Gas, other than medical gas, for nonmedical laboratory facility applications.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Tubes and fittings.
   2. Valves.
   3. Gas manifolds.
   4. Specialty gas cylinders. Include rated capacities and operating weights.
   5. Gas cylinder storage racks.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Piping Material Certification: Signed by Installer certifying that medical gas piping materials comply with NFPA 99 requirements.

D. Qualification Data: For Installer and testing agency.

E. Brazing certificates.

F. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For specialty gas piping specialties to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. ASME Compliance: Fabricate and label bulk medical gas storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

F. CGA Compliance: Comply with CGA G-8.1, "Nitrous Oxide Systems at Consumer Sites," for bulk nitrous oxide storage tanks.

G. UL Compliance: Comply with UL 498, "Attachment Plugs and Receptacles," for electrical service connections.
   1. Comply with UL 544, "Medical and Dental Equipment," for medical gas specialties.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate gas service connections with other service connections. Compressed-air service connections are specified in Division 22 "Compressed Air Piping for Laboratory Facilities."

PART 2 PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type K, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

B. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   2. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

2.02 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

2.03 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. BeaconMedaes.
      b. Conbraco Industries, Inc.
      c. NIBCO INC.
   2. Pressure Rating: 300 psig minimum.
   3. Ball: Full-port, chrome-plated brass.
   4. Seats: PTFE or TFE.
   5. Handle: Lever type with locking device.
   6. Stem: Blowout proof with PTFE or TFE seal.
   7. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

C. Check Valves: In-line pattern, bronze.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amico Corporation.
      b. BeaconMedaes.
      c. Conbraco Industries, Inc.
      d. Squire-Cogswell/Aeros Instruments, Inc.
      e. Tri-Tech Medical.

2. Pressure Rating: 300 psig minimum.
3. Operation: Spring loaded.
4. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

D. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.

E. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated, relieving type; manual pressure-setting adjustment; rated for 250-psig minimum inlet pressure; and capable of controlling delivered gas pressure within 0.5 psig for each 10-psig inlet pressure.

2.04 GAS MANIFOLDS

A. Duplex Specialty Gas Manifolds:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. BeaconMedaes
b. Concoa Precision Gas Controls
c. Airgas, Inc.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Central Control-Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm-system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.
4. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig minimum inlet pressure, cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
5. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.
6. Mounting: Wall with mounting brackets for manifold control cabinet and headers.
7. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
8. Carbon Dioxide Manifold: For four-cylinder capacity at 55-psig line pressure, with electric heater or orifice design that will prevent freezing during high demand.
9. Nitrogen Manifold: For four-cylinder capacity at 55-psig line pressure, with electric heater or orifice design that will prevent freezing during high demand.
10. Oxygen Manifold: For four-cylinder capacity at 55-psig line pressure, with electric heater or orifice design that will prevent freezing during high demand.

B. Specialty Gas Cylinders: Number and type of specialty gas cylinders required for complete manifold systems.
1. Specialty Gas Cylinders: Furnished by Owner.

C. Building Automation System Interface:
1. Provide interface to the building automation system. Coordinate requirements with BAS provider. Building automation system is specified in Section 23 09 00 "Building Automation System."
2. All monitoring and control features, which are available at the Central Control-Panel Unit, shall also be available remotely through the building automation system.
3. At a minimum, include the following:
a. Status
b. Alarm - Changeover
c. Alarm - Reserve In Use
d. Alarm - Low Pressure.
e. Alarm – Routine Maintenance.

2.05 GAS CYLINDER STORAGE RACKS

A. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.

B. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.

PART 3 EXECUTION

3.01 PREPARATION

A. Cleaning of Lab Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction, perform the following procedures:
   1. Clean Lab gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
   2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
      a. Scrub to ensure complete cleaning.
      b. Rinse with clean, hot water to remove cleaning solution.

3.02 PIPING APPLICATIONS

A. Specialty Gas Piping: Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.03 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Comply with ASSE Standard #6010 for installation of medical gas piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.

H. Install piping to permit valve servicing.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.

L. Install unions, in copper tubing adjacent to each valve and at final connection to each piece of equipment and specialty.

M. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

N. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.04 VALVE INSTALLATION

A. Install shutoff valve at each connection to gas laboratory equipment and specialties.

B. Install check valves to maintain correct direction of gas flow from laboratory gas supplies.

C. Install pressure regulators on gas piping where reduced pressure is required.

3.05 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free, dry nitrogen during brazing.

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Vertical Piping: MSS Type 8 or 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:
1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

E. Base of Vertical Piping: MSS Type 52, spring hangers.

F. Support horizontal piping within 12 inches of each fitting and coupling.

G. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1/4: 60 inches with 3/8-inch rod.
2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
3. NPS 3/4: 84 inches with 3/8-inch rod.
4. NPS 1: 96 inches with 3/8-inch rod.
5. NPS 1-1/4: 108 inches with 3/8-inch rod.
6. NPS 1-1/2: 10 feet with 3/8-inch rod.
7. NPS 2: 11 feet with 3/8-inch rod.
8. NPS 2-1/2: 13 feet with 1/2-inch rod.
9. NPS 3: 14 feet with 1/2-inch rod.
10. NPS 3-1/2: 15 feet with 1/2-inch rod.
11. NPS 4: 16 feet with 1/2-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

3.07 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.08 FIELD QUALITY CONTROL FOR LABORATORY FACILITY SPECIALTY GAS

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of specialty gas piping for laboratory facilities and prepare test reports.

B. Perform field tests and inspections of specialty gas piping for laboratory facilities and prepare test reports.

C. Tests and Inspections:
   1. Piping Leak Tests for Specialty Gas Piping: Test new and modified parts of existing piping. Cap and fill specialty gas piping with oil-free, dry nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect specialty gas regulators for proper operation.

3.09 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.10 PIPING SCHEDULE

A. Flanges may be used where connection to flanged equipment is required.

B. Specialty Gas Piping:
   1. Carbon Dioxide: Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.
   2. Oxygen: Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.
   3. Nitrogen: Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.11 VALVE SCHEDULE

A. Shutoff Valves: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

3.12 DEMONSTRATION

A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas manifolds and tanks.

END OF SECTION

SECTION 22 66 00 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Single-wall piping.
   2. Piping specialties.

1.02 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. FPM: Vinylidene fluoride-hexafluoro propylene copolymer rubber.

C. CPVC: Chlorinated Polyvinyl Chloride

1.03 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet head of water.

B. Delegated Design: Design seismic restraints for aboveground piping, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and vertical scale of not less than 1 inch equals 5 feet. Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.

D. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between piping and proximate structures.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For chemical-waste specialties and neutralization systems to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."

1.06 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Neutralization tank limestone: Equal to 200 percent of amount required for each tank sump initial charge. Furnish limestone in 50 lb bags.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, fittings, and seals from dirt and damage.

PART 2 PRODUCTS

2.01 SINGLE-WALL PIPE AND FITTINGS

A. PP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded, and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion- and mechanical-joint ends.
   1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. IPEX Inc.
      b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
      c. Sloane, George Fischer Inc.
      d. Enfield
      e. Watts Industries (Canada) Inc.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.02 JOINING MATERIALS

A. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

2.03 PIPING SPECIALTIES

A. Plastic Dilution Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. IPEX Inc.
      b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
      c. Sloane, George Fischer Inc.
      d. Enfield.
   2. Material: Corrosion-resistant PP, with removable base.
   3. End Connections: Mechanical joint.
   4. Dilution Tanks: 1-gal. capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 top inlets and one NPS 1-1/2 side outlet.
   5. Small Dilution Jars: 1-pint capacity, with clear base unless colored base is indicated; with NPS 1-1/2 top inlet and NPS 1-1/2 side outlet.
   6. Large Dilution Jars: 1-quart capacity; with NPS 1-1/2 top inlet and NPS 1-1/2 side outlet.

B. PP Floor Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. IPEX Inc.
      b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
      c. Schier Products Company.
      d. Sloane, George Fischer Inc.
      e. Enfield.
      f. Watts Industries (Canada) Inc.

2. Body: With 7- to 9-inch top diameter, with flashing flange and weep holes; and with flashing clamp basket strainer funnel attachment (as noted on drawings) and trap-primer connection.
3. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, or NPS 4 outlet as indicated.

C. PP Sink Outlets:
1. Description: NPS 1-1/2, with clamping device, stopper, and 7-inch- high overflow fitting.

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:
1. Piping shall be used for laboratory sinks that require neutralizers. Piping shall be install between the sink drain and the neutralizer.
2. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
3. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
4. Flanges may be used on aboveground piping unless otherwise indicated.
5. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
6. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
7. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
8. Install piping at indicated slopes.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."
14. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Firestopping" for materials.
15. Verify final equipment locations for roughing-in.

3.02 PIPING SPECIALTY INSTALLATION

A. Embed floor drains in 4-inch minimum depth of concrete around bottom and sides. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for concrete.

B. Fasten grates to drains if indicated.

C. Set floor drains with tops flush with pavement surface.

D. Install cleanouts and riser extension from sewer pipe to clean out at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

3.03 JOINT CONSTRUCTION

A. Chemical-Waste Piping Inside the Building:

1. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.

3.04 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping.

B. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

C. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hangers and support devices. Install the following:
   1. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

D. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

F. Support vertical piping and tubing at base and at each floor.

G. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch.

H. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 2: 33 inches with 3/8-inch rod.
   2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6: 48 inches with 3/4-inch rod.
   5. NPS 8: 48 inches with 7/8-inch rod.

I. Install support for vertical PP piping every 72 inches.

J. Support piping and tubing not listed above according to MSS SP-69.

3.05 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified.

B. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.

D. Install piping adjacent to equipment to allow service and maintenance.

3.06 LABELING AND IDENTIFICATION

A. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.

3.07 FIELD QUALITY CONTROL

A. Inspect the interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.
   1. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.
d. Hydrostatic Tests for Drainage Piping:
1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
2) Close the openings in system and fill with water.
3) Purge air and refill with water.
4) Disconnect water supply.
5) Test and inspect joints for leaks.
e. Air Tests for Drainage Piping: Comply with UNI-B-6.
2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safety. Replace damaged and malfunctioning controls and equipment.

E. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.08 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service for neutralization systems.
1. Complete installation and startup check according to manufacturer's written instructions.
2. Neutralization Systems:
a. Verify that neutralization system is installed and connected according to the Contract Documents.
b. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
c. Install neutralizing solutions and limestone.
d. Energize circuits.
e. Start and run systems through complete sequence of operations.
f. Adjust operating controls.

3.09 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before use.
2. Clean piping by flushing with potable water.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain neutralization systems.

3.11 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Single-Wall, Chemical-Waste Sewerage Piping: Use the following piping materials for each size range:
   1. Piping in first two subparagraphs below is not available in NPS 1-1/2 (DN 40).
   2. NPS 1-1/2 to NPS 4: PP drainage pipe and fittings and electrofusion joints.
   3. Piping in first subparagraph below may not be available in NPS 1-1/2 (DN 40).
   4. NPS 6: PP drainage pipe and fittings and electrofusion joints.

C. Aboveground Chemical-Waste Piping: Use the following piping materials for each size range:
   1. NPS 1-1/2 to NPS 6: PP drainage piping and electrofusion joints.

D. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use the following piping materials for each size range:
   1. NPS 1-1/2 to NPS 6: PP drainage piping and electrofusion joints.

END OF SECTION

SECTION 23 01 00 - COMMON WORK RESULTS FOR MECHANICAL

PART 1 GENERAL

1.01 SUMMARY

A. This Section describes the common work requirements for the mechanical work included in Division 23 and applies to all sections of Division 23.

1.02 SUSTAINABLE DESIGN REQUIREMENTS – GREEN GLOBES

A. The Owner is pursuing Green Building Initiative (GBI) Green Globes for New Construction (NC) Certification.

B. Submit documentation to GBI-authorized Assessor and respond to questions and requests from GBI-authorized Assessor about Green Globes credits that are the responsibility of Contractor, that depend on product selection or product qualities, or that depend on Contractor's procedures until GBI-authorized Assessor has made its determination on Project's Green Globes certification application.

C. Document correspondence with GBI-authorized Assessor as informational submittals.

D. Refer to Division 1 sustainable design requirements for additional information.

1.03 COMMISSIONING

A. The Owner is pursuing Green Building Initiative (GBI) Green Globes for New Construction (NC) Certification. The scope of the commissioning effort is that which is required to facilitate fulfilling Fundamental Commissioning of the Building Energy Systems and Enhanced Commissioning.

B. All building energy-related systems shall be commissioned in order to verify and ensure that fundamental building elements and systems are installed, constructed, calibrated to operate, and perform according to the Owner’s Project Requirements, Basis of Design, and Construction Documents.

C. Refer to Divisions 1 and 23 commissioning specifications for additional information.

1.04 DEFINITIONS

A. Following are definitions of terms and expressions used in the Mechanical and Electrical Sections:

1. Provide: Furnish and install
2. Directed: Directed by the Architect or Engineer
3. Indicated: Indicated in Contract Documents
4. Concealed: Hidden from normal sight; includes items within furred spaces, pipe and duct shafts, above suspended ceilings and within return air plenums.
5. Exposed: Non-concealed - Work within Equipment Rooms shall be considered exposed.
6. Exterior: Items being or situated outside. Items located within a crawl space shall be considered exterior.
7. Conditioned: Heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means, so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.
8. Piping: Includes pipes, fittings, valves, hangers, and accessories comprising a system.
9. Ductwork: Includes ducts, fittings, housings, dampers, hangers, air devices, and accessories comprising a system.
10. Architect: Principal design professional for the project. In certain types of projects, the principal design professional may be an engineer rather than an architect. For such projects, within the bounds of these specifications, where the term “architect” is used, it may refer instead to the engineer.

1.05 CODES, REGULATIONS, AND PERMITS:

A. References to codes, standards, specifications, and regulations apply to the latest edition adopted by the jurisdiction where the project is located.

B. Give all necessary notices, obtain all permits, and pay all fees and other costs, including those for utility connections or extensions in connection with the work. File all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments having jurisdiction. Obtain all required certificates of inspection and deliver same to the Architect before request for acceptance and final payment for the work.

1.06 EQUIPMENT LIST

A. Provide a spreadsheet list of all equipment provided with the drawing tag number or designation, name, manufacturer, model number, serial number and full electrical characteristics.

B. This list shall be provided to the TAB agent, Commissioning Agent, BAS providers and to the Owner prior to beginning TAB work and as soon after all equipment is received on site.

1.07 EQUIPMENT START-UP AND INITIAL OPERATION

A. No equipment shall be operated, for testing or trial use, before full compliance with the equipment manufacturers' specifications and instructions for the lubrication, alignment, direction of rotation, balance, and other applicable considerations.

B. Particular care shall be taken to see that all equipment is completely assembled, properly lubricated, and all grease and oil cases and reservoirs have been filled to the correct level with the recommended lubricants.

C. It is the Contractor's responsibility to place each item of equipment, installed by him, in operating condition. This responsibility includes all auxiliaries, piping, wiring, etc., the start up of each unit, and a check of its performance.

1.08 TEMPORARY HEATING AND COOLING:

A. WTCC prefers that contractors NOT be allowed to use new HVAC equipment during construction.

B. Provide temporary heating and cooling required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity.

C. Select equipment that will not have a harmful effect on completed installations or elements being installed.

1.09 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Refer to Section 017900 "Demonstration and Training" for additional information.

B. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment.

C. Contractor shall instruct the Owner's representative fully in the operation, adjustment, and maintenance of all equipment furnished.

1.10 DRAWINGS

A. The Contract Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Any offsets, rises, or transitions not shown on the drawings and required to provide a complete system shall be provided at no additional contract cost. Do not scale the drawings. Consult the Architectural and Structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

B. In the event of ambiguities within or between parts of the Contract Documents, the contractor shall 1) provide the better quality or greater quantity of work, or 2) comply with the more stringent requirement, either or both in accordance with the Architect's interpretation.

1.11 ELECTRICAL WORK

A. Under Division 23 MECHANICAL, provide the following items of electrical work which shall conform with the applicable requirements of the Electrical Division:
   1. Class 2 (24VAC or less) temperature control wiring.
   2. Interlock wiring for mechanical equipment and devices.
   3. IT/network cabling between the BAS and Owner/Agency IT network.

B. Under Division 26 ELECTRICAL, provide:
   1. Power wiring, complete from power source to motor or equipment junction box, including power wiring through motor starters, power factor correction devices, and line reactors. Power factor correction devices shall be provided under Division 23 and installed under Division 26.
   2. Motor control centers or motor starter, panelboards.
   3. All miscellaneous individual motor starters, unless noted or specified otherwise.

1.12 SINGULAR NUMBER

A. Where any device or part of equipment is herein referred to in the singular number (such as "valve"), such reference applies to as many such devices as are required to complete the installation as shown on the drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe and fittings shall be from a United States domestic manufacturer.

2.02 FIRE-RATED PENETRATIONS

A. Provide UL Listed fire penetration systems in openings in rated floors, walls, and other elements of construction. Provide UL listed fire penetration systems at all new and existing pipe penetrations of new and existing rated construction within the area of work. Coordinate work of this section with all other trades necessary for the proper installation of the fire rated penetration systems.

B. Submit shop drawings showing each condition requiring penetration seals in dictating proposed UL systems materials, anchorage, methods of installation, and actual adjacent construction. Submit a copy of UL illustration of each proposed system indicating manufacturer approved modifications. Submit copies of manufacturer's specifications, recommendations, inspection requirements, installation instructions, and maintenance data for each type of material required. Include letter indicating that each material complies with the requirements and is recommended for the applications shown.

C. All fire penetration systems shall reference ASTM E814/UL 1479 - Fire Test of Through - Penetration Fire Stops.

D. All systems shall be UL tested and listed in the UL Fire Resistance Directory.

E. Submit copies of written guarantee agreeing to repair or replace joint sealers which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be one (1) year from date of substantial completion.

F. 3M products have been specified as the penetration fire stop basis of design. Other manufacturer's systems are acceptable providing they meet the requirements set forth in this specification. The fire rated penetration systems shall be the products of one manufacturer to the maximum extent possible. The products of more than one manufacturer shall not be used as a combined seal.

G. Provide materials classified by UL to provide fire stopping equal to time rating, both "F" and "T" ratings, of construction being penetrated. Provide asbestos free materials that comply with applicable codes and have been tested under positive pressure in accordance with UL 1479 or ASTM E814. Systems shall be smoke and air tight.

H. Deliver material undamaged in manufacturer's clearly labeled, unopened containers identified with brand, type, grade, and UL label where applicable. Coordinate delivery with scheduled installation date to allow minimum storage time at site. Store material in clean, dry ventilated location. Protect from soiling, abuse, and moisture. Follow manufacturer's instruction.

I. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

J. Furnish adequate ventilation if using solvent. Furnish forced air ventilation during installation if required by manufacturer. Keep flammable materials away from sparks or flame. Provide masking and drop cloths to prevent contamination of adjacent surfaces by fire stopping resistance.

K. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose, materials, rust, or other substances that may affect proper fitting, adhesion of the required fire resistance.

L. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instructions. Seal holes or voids made by penetrations to ensure an effective smoke barrier. Where floor openings without penetrating items are more than four (4) inches in width and subject to traffic or loading, install fire stopping materials capable of supporting same loading as floor. Protect materials from damages on surfaces subject to traffic.

M. Clean up spills of liquid components. Neatly cut and trim materials as required. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.

N. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities. Perform under this section patching and repairing of fire stopping caused by cutting or penetration by local inspectors and other trades.

2.03 DRIVES FOR MACHINERY

A. Equip each motor driven machine with a V-belt drive except those which are specified as direct drive. Where factory designed and assembled belt drives which do not conform to the following are proposed to be furnished, such non-conformity must be noted on the shop drawings submittals and may be cause for rejection of the item.

B. Provide OSHA approved guards, for all belt drives, constructed in accordance with SMACNA standards. Submit shop drawings for approval.

C. Select each drive according to the ratings and recommendations of the manufacturer for the service with which used, giving proper allowance for sheave diameter, center distance, and arc of contact less than one hundred eighty degrees. Size the motor driving a pump or fan to have a nameplate rating of not less than ten (10) percent above the total of actual brake horsepower and drive loss at specified capacity.

D. Belts shall be constructed of endless reinforced cords of long staple cotton, nylon, rayon, or other suitable textile fibers imbedded in rubber. Use belt with correct cross section to fit properly the sheave grooves. Carefully match belts for each drive.

E. Provide any changes to the sheaves, belts, pulleys or drive package to obtain specified airflow.

F. Select the motor of a capacity needed to operate the equipment at the specified mid-position operating condition. Where non-overloading motors are specified, select the motor capacity rating at the most closed position of the motor sheave. In no case shall motors be a smaller size than those indicated on the drawings.

G. Do not select fan sheave smaller in diameter than thirty (30) percent of the fan wheel diameter.

H. Construct sheaves of cast iron or steel, bored to fit properly on the shafts, and secured with key ways of proper size (not set screws). Key ways may be omitted for sheaves having 1/2 inch or smaller bores where set screws may be used.

PART 3 EXECUTION

3.01 WORKMANSHIP

A. The quality of workmanship required, for each trade, in the execution of work shall be the finest and highest obtainable in that trade working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality is final.

B. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.02 EQUIPMENT PERFORMANCE

A. All equipment, devices, controls, and hardware shall be proven to operate successfully throughout the guarantee period. Systems shall be proven during all-weather seasons and be demonstrated to affect the design conditions at times. System components or equipment items that fail to consistently deliver the design conditions shall be removed and replaced as directed by the Architect. The cost of required equipment replacements shall be borne by the Contractor.

B. All equipment shall be tested after installation and be proven to deliver the manufacturers quoted design capacity. When capacity is in question as deemed by the Architect, the Contractor shall perform a detailed and comprehensive field performance test to certify the equipment capacity. System effect or installed performance factors may not be applied to performance ratings unless they were previously included when the equipment was submitted for approval. Equipment that fails to deliver manufacturers quoted design capacity shall be removed and replaced at the Contractors expense.

C. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.03 EQUIPMENT CONNECTIONS

A. All equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, piping specialties, water seals, valves, and electric connections recommended by the manufacturer, required by code or required for proper operation shall be provided.

3.04 CUTTING AND PATCHING

A. Cutting and patching associated with the work shall be performed in a neat and workmanlike manner. Existing surfaces, which are damaged by the Contractor, shall be repaired or provided with new materials. All patching shall be done with materials and methods similar to existing adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary, non-percussive methods.

B. Patching of areas disturbed by installation of new work shall match existing adjacent surfaces in material, texture, and color.

3.05 PROTECTION OF EXISTING WORK

A. When working in and around the building, extreme care shall be exercised with regard to protection of the structure and mechanical services. Repair or replace, to the satisfaction of the Architect, any existing work damaged in the performance of the new work.

3.06 SURVEYS AND MEASUREMENTS

A. Base all measurements (both horizontal and vertical) from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check correctness of same as related to the work. Verify locations of existing utilities and inverts of same prior to the start of any systems shown connecting to existing utilities.

B. Should the Contractor discover any discrepancy between actual measurements or conditions, and those indicated, which prevent following good practice or the intent of the drawings and specifications, he shall notify the Architect and shall not proceed with his work until he has received instruction from the Architect.

3.07 WELDING

A. Welding shall conform to current standards and recommendations of the National Certified Pipe Welding Bureau, with all North Carolina Occupational Safety and Health Acts, State, City and County Fire Prevention Code Requirements, and NFPA Standard 241 including provision of appropriate portable fire extinguishers.

B. Before assigning any welders to work covered by this specification, the Contractor shall provide the Architect with the names of pipe welders to be employed for the work, together with each welder's assigned number, letter, or symbol which shall be used to identify the work of that welder and which shall be affixed immediately upon completion of each weld. Contractor shall also submit, with the list of names, copies of each welder's certified qualification tests prescribed by the National Certified Welding Bureau or by other reputable testing laboratory using procedures covered in the American Society of Mechanical Engineers Building Construction Code, Section IX, "Qualification Standard Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators". Welders must be certified for all positions.

C. If requested by the Architect, the Contractor shall submit identifying stenciled test coupons made by any welder in question. The Contractor shall require any welder to retake the tests when, in the opinion of the Architect, the work of the welder creates a reasonable doubt as to his proficiency. Tests, when required, shall be conducted at no additional expense to the Owner; and the welder in question shall not be permitted to work as a welder on this project until he has been recertified. Recertification of the welder shall be made to the Architect only after the welder has taken and passed the required test; welder must pass the test without benefit of retests in order to resume work as a welder on this project.

D. Welding shall conform to the ANSI Code for Pressure Piping ANSI B31.9, Building Services Piping. The Contractor shall be responsible for the quality of welding and shall repair or replace any work not in accordance with these specifications. Contractor shall, without cost to the Owner, check welds by radiograph, ultrasonic testing, sectioning or a combination of these methods wherever there is a question raised by the Architect as to the quality of a weld. Examination of the questionable weld shall be in addition to other system tests specified. Welds shall have penetration complete to the inside diameter of the pipe. The recommended spacing and levels between ends of pipes prior to welding shall be used in all cases to assure full penetration.

E. Welders on pressure piping shall be certified and carry their identification stamp with them. Welds on lines with operating pressures above 100 psig shall be stamped.

3.08 HANDLING AND STORAGE OF MATERIAL

A. Proper and suitable tools, equipment and appliances for the safe and convenient handling and placing of all materials and equipment shall be used. During loading, unloading, and placing, care shall be taken in handling the equipment and materials so that no equipment or materials are damaged.

B. All equipment delivered to the job site shall be stored on pedestals, above the ground and under roof or other approved covering. All enclosures for equipment shall be weatherproof. All motors, drives, switchgear, panels, etc. which are not totally enclosed, that are involved in the work, shall be stored in a heated, dry, water protected area with a minimum temperature of fifty

degrees (50) Fahrenheit. All valves shall be stored under roof on wood pedestals, above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.

C. If any equipment and/or materials are found to be in poor condition at the time of installation the Architect may, at his discretion, order the Contractor to furnish and install new equipment and/or material at no cost to the Owner.

3.09 COOPERATION WITH OTHER TRADES

A. Mechanical trades shall give full cooperation to other trades and shall furnish in writing, with copies to Architect any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. Exact location of all mechanical and equipment, devices, etc. in finished spaces shall be coordinated with Architectural reflected ceiling plans, elevations and details.

3.10 CLEANING AND PAINTING

A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition.

B. Restore and touch-up factory finishes which have been damaged during construction.

C. For areas of exposed rust, treat with water-based emulsion chemical rust converter. Brush, roll, or spray on the surface to be treated and allow to cure prior to paint/surface touch-up. Basis of design is Ultra Last CuRUST Chemical Rust Converter.

D. Cleaning Solutions: Cleaning solutions used to clean and flush piping systems or equipment shall not be discharged to the storm sewer system.

3.11 ACCESSIBILITY

A. Equipment shall be installed per manufacturer’s recommended clearance guidelines with sufficient space for maintenance personnel service, operate, and maintain equipment.

B. Maintenance Accessibility HVAC Equipment:
   1. Clearances around HVAC equipment located above or below ceilings including but not limited to VAV boxes, reheat coils, fan coil units, exhaust fans, pumps, air handling units, boilers, chillers, etc. shall be sufficient to allow inspection, service, repair or replacement without removing elements of permanent construction and in accordance with the manufacturers recommended clearances.
   2. The contractor shall coordinate with all other trades to protect the service area around equipment.
   3. In office areas, VAV boxes are not to be placed directly over a fixed podium, desk or table or over/adjacent to a light fixture.
   4. Do not locate VAV boxes adjacent to interior partitions or exterior walls without providing the manufacturers recommended clearances.

C. Access Panels:
   1. All HVAC equipment, dampers, detectors, valves, etc. needing servicing, filter changing, occasional access, etc. should be located above accessible lay-in ceilings as much as practical.
   2. If it is necessary to mount equipment above any drywall ceilings, or concealed within walls, provide suitable access panels appropriately sized and located to maintain the equipment.

D. Maintenance Clearances:
   1. Contractor shall provide the manufacturer’s recommended clear maintenance access for all pieces of major equipment including air handlers, terminal units, heat exchangers, boilers, chillers, air compressors, pumps, motors, fans, control valves (greater than 3”), etc.

2. Specific requirements which follow may exceed manufacturer's recommendations:
   a. Air Handlers: 36 inches minimum access for fan compartments with motors 10 hp and larger. Also provide coil pull access for the depth of the coil plus 18 inches and the width of the coil plus 30 inches on both sides.
   b. Boilers: Provide 24 inches on all sides except the burner, which should have 36 inches minimum.
   c. Control valves: For valves 3 inches and larger, provide access above the valve of the assembly height plus 12 inches. Install ALL control valves in the vertical position, unless otherwise required by the manufacturer.
   d. Heat Exchangers: Provide tube pull plus 12" for shell and tube type exchangers.
3. Provide a means and a pathway for replacing all equipment without major demolition including removing permanent elements of construction.

E. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner.

3.12 EXCAVATION AND BACKFILL

A. Refer to Section 312000 "Earth Moving" for additional requirements.

B. Definitions
1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   a. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   b. Final Backfill: Backfill placed over initial backfill to fill a trench.
2. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
3. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
4. Fill: Soil materials used to raise existing grades.
5. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
6. Utilities: On-site underground pipes, as well as underground services within buildings.

C. Soil Materials
1. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter
2. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.
   a. Unsatisfactory soils include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
3. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
4. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
5. Sand: ASTM C 33/C 33M; fine aggregate.

D. Excavation for Utility Trenches
1. Excavate trenches to indicated gradients, lines, depths, and elevations.
   a. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

2. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe unless otherwise indicated.
   a. Clearance: 12 inches each side of pipe.
3. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes on solid, undisturbed earth for the full length of each pipe, except for that portion at the bell holes. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes. Remove projecting stones and sharp objects along trench subgrade.
   a. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
   b. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
   c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
   d. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
4. Any part of the trench bottom excavated below the specified subgrade shall be backfilled, at the Contractor's expense, with bedding course materials.
   a. For utility trenches, compact bedding course soil material at 95 percent.
5. Whenever wet, or otherwise unstable, subgrade is encountered below the elevation of the original ground surface which existed prior to the time of construction, such soil shall be removed to the depth and extent direct by the Architect and the trench backfilled to the proper grade with bedding material as hereinafter specified. Reimbursement for extra work performed by the Contractor shall be in accordance with the General Conditions.
6. Provide shoring and sheet piling necessary for excavation and for the safety of personnel and property as directed. Unless otherwise directed, the sides of all excavations over four (4) feet deep must be braced. All shoring, bracing, sheet piling, etc., must be solidly installed heavy timber suitable for the purpose. No lumber shall be buried when excavations are backfilled, except by authority of the Architect.

E. Subgrade Inspection
1. Notify Architect when excavations have reached required subgrade.
2. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
3. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

F. Utility Trench Backfill
1. No backfill and/or bedding shall be placed until the construction adjacent thereto or the utility to be backfilled has been inspected, tested and approved. Notify the Architect when inspections are required.
2. Place backfill and beddings on subgrades free of mud, frost, snow, or ice.
3. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes.
4. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03.
5. Trenches under Roadways: Provide 4-inch- thick, concrete-base slab support for piping less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03.
6. Backfill voids with satisfactory soil while removing shoring and bracing.
7. Initial Backfill:

a. Soil Backfill: Place and compact initial backfill of subbase material or satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe.
   1) Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping to avoid damage or displacement of piping.
   2) Backfill for plastic pipe shall be clean sand, free of foreign materials.
   3) Coordinate backfilling with utilities testing.

8. Final Backfill:
   a. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
9. Whenever the Architect requires the removal of wet or otherwise unstable subgrade from the fill material previously placed by the Contractor, the cost of all removal of unstable soil, together with backfilling of the trench as herein specified shall be borne by the Contractor.
10. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

G. Compaction of Soil Backfills and Fills
1. Following inspection as specified above, approved backfill material shall be deposited in the trench with hand shovels, not by means of wheelbarrows, carts, trucks, bulldozers, or similar equipment.
2. Place backfill and fill soil materials in layers not more than 4 inches in loose depth for material compacted by hand-operated tampers until the pipe has a cover of not less than two (2) feet. The remainder of the backfill material shall then be deposited in the trench in eight (8) inch layers and compacted.
3. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
4. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698 and ASTM D 1557:
   a. For utility trenches, compact each layer of initial and final backfill soil material at 95 percent of dry weight compaction.
5. Mechanical tampers, for compacting backfill, shall be tampers capable of exerting a blow equal to 250 foot-pounds per square foot (FT2) of area of the tamping face.
6. Work broken or ruptured by improperly placed backfill shall be removed and replaced by the Contractor at no additional cost to the Owner.
7. Any trenches improperly backfilled shall be reopened, then refilled and compacted to the required grade and smoothed off.

H. Field Quality Control
1. Test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
   a. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 100 feet or less of trench length but no fewer than two tests.
2. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.13 EQUIPMENT BASES AND SUPPORTS

A. Concrete bases, curbs, and supports will be furnished and installed under this Division and shall be in accordance with Division 3.

B. The Subcontractors shall furnish, to the General Contractor, all required foundation sizes, bolts, washers, sleeves, plates and templates for equipment.

C. The size of the foundation bolts shall be as recommended by the manufacturer.

D. All equipment shall be set on the foundations, shimmed level with steel shims, and grouted up under base for uniform bearing by the Subcontractor.

E. Under this Section, provide all equipment supports; consisting of inertia pads, platforms, gratings, structural members and related materials required for the mechanical and electrical work.

F. The type and size of the supporting channels and supplementary steel shall be determined by the Subcontractor and shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.

3.14 MOLD AND CONDENSATION PREVENTION DURING CONSTRUCTION

A. Piping Systems: Cold piping systems shall not be operated prior to insulation and vapor barrier installation in order to prevent condensation on the piping.

B. Air Systems: Air handling systems shall not be operated prior to insulation and vapor barrier installation in order to prevent condensation on the ductwork. Air systems shall not be operated in portions of the building not yet fully enclosed, where systems can be exposed to warm, humid air conditions.

C. Room thermostats shall not be set lower than 72 degrees F.

D. Contractor shall notify the Architect immediately if signs of condensation or mold are discovered.

3.15 ATTIC STOCK:

A. All HVAC related attic stock shall be stored in an alternate location from the building or area under construction and turned over to the OWNER at the completion of the project, along with attic stock from the other trades packages.

END OF SECTION

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, induction motors for use on alternating-current power systems and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.02 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

1.03 SUBMITTALS

A. Shop Drawings and Product Data: Shop drawings and product data for motors shall be provided with the submittal package for the piece of equipment that it serves. In accordance with Division 01, Section “Submittals” provide the following:
   1. Product catalog data: nameplate data and ratings; materials of construction; mounting arrangement, size and location of motor terminal box and conduit entry, grounding lugs and coatings.

B. Warranties
   1. In addition to the warranty requirements of the General Conditions, warranties for each motor shall be covered in the warranty for the entire mechanical assembly (fan & motor, pump and motor, etc).

C. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 23, Section "Mechanical Vibration, Sound and Seismic Controls.” Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Operation and Maintenance Data: For factory-installed motors to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain factory-installed motors through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, "National Electrical Code."

D. NRTL Listing: Motors shall be NRTL-listed.
   1. Term "Listed": As defined in "National Electrical Code," Article 100.

2. Listing Agency Qualifications: "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.

E. Comply with NEMA MG 1, "Motors and Generators."

F. Comply with UL 1004, "Motors, Electric."

G. Provide factory test reports in accordance with Part 2 of this Section.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Whenever possible, motor and driven equipment shall be shipped complete as an entire assembly.

B. Inspect equipment immediately upon arrival and any irregularities or damage shall be reported to the Manufacturer/Supplier immediately.

C. Store in accordance with manufacturer's recommendations.

1.06 IDENTIFICATION

A. Nameplates: All motors shall have a stainless steel nameplate attached with stainless steel fasteners on the motor. The nameplate shall be stamped with nameplate markings listed in NEMA MG 1 20.60, plus the following:
1. Manufacturer
2. Model Number
3. Serial Number
4. Nominal efficiency
5. Minimum efficiency
6. Temperature Rise
7. Bearing manufacturer's name and catalog number

PART 2 PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Motor requirements apply to factory-installed motors except as follows:
1. Different ratings, performance, or characteristics for motor are specified in another Section.
2. Motorized-equipment manufacturer requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

C. Contractor assumes responsibility for the correct direction of rotation required by the equipment drives. In the event of damage due to reverse rotation, the equipment shall be repaired or replaced at no charge to the Owner.

D. Motor Bearings: Motor bearings shall be specifically designed for the drive application, and shall be approved by the Engineer. Bearings shall have a minimum bearing life of B-10 or L-10 as defined by the AFBMA. Bearings shall be designed to carry the total hydraulic and static thrust developed by the driven load. Bearings shall be grease or oil lubricated. Oil lubricated motors shall be fitted with gravity-feed oil reservoirs. Grease lubricated bearings shall be re-greasable (not sealed) and shall be supplied with grease fittings and drain plugs. Medium voltage and variable frequency controlled motor bearings shall be electrically isolated from the shaft on at least one end to prevent transmission of electric current. Current drain brushes shall be fitted where it is necessary to divert the flow of electrical current from bearings. Bearings, housing and brackets shall be constructed to permit access, removal and replacement of the bearings without disassembly of the motor.

E. Rotor: The rotor shall be dynamically and statically balanced. Assembled motor shall be tested at the factory in accordance with latest applicable NEMA MG 1and IEEE 112 methods of testing, and balanced at no more than 0.001 inches total peak-to-peak deflection on the bearing

housing and the shaft. Overall vibration readings, including all vibration frequencies, shall be taken and recorded at no load and design speed.

F. Terminal Box: Motors shall have a watertight cable terminal box. Terminal box shall be oversized, diagonally split, and rotatable in 90o increments to allow conduit and cable entry from top, bottom and sides.

G. Motor Leads: Motor leads shall be a minimum of 6 inches in length. All motor leads shall be extended from the conduit box. Motors rated over 200 HP or over 600V shall have insulated tin plated copper busbar terminals with bolt holes for compression wire lugs.

H. Drains and Breathers: Provide drain(s) in the bottom of the motor at the lowest point(s). Enclosed motors shall be fitted with breathers.

I. Screens: Provide stainless steel screens at motor ventilation openings.

J. Motor Shaft: The motor shaft shall be ASTM A322 GR140 (AISI 4140) steel and shall be sized to accommodate the required power and torque. Provide shaft end with keyway for connection to coupling with the pump shaft. Coordinate shaft design requirements with driven load.

K. Stainless Steel Hardware: Provide corrosion resistant hardware for motor components including grease fittings, plugs, nuts, bolts, washers and screws.

L. Motor Casing and Coating: Housings shall be degreased, primed and painted both inside and outside with a rust inhibitive primer and corrosion resistant polyester paint. Painting shall be performed prior to installing the motor stator windings. The primer and paint materials selected shall be suitable for the environment encountered, both inside and outside of the casing.

M. Motors connected to Variable Frequency Drives shall be “inverter duty” with additional magnet wire insulation to achieve a minimum motor impulse voltage rating equal to the VFD manufacturer’s recommendations for the motor, cable size, and cable length installed.

N. Shaft Grounding Ring: Each motor shaft shall be provided with a Shaft Grounding Ring (SGR) that will provide a reliable low resistance path from the motor shaft to the motor frame to prevent the buildup of destructive high frequency shaft currents that are created by the Pulse Width Modulation of the Variable Frequency Drive units. The SGR shall encircle the shaft and shall be designed to promote efficient discharge of the high frequency shaft currents to the motor frame. The motor frame shall be inherently grounded by design.

O. Power Factor Correction Capacitors: Provide motor power factor correction capacitors for all motors rated 600V or less (except variable frequency-controlled motors) with less than 90% uncorrected power factor. Motor power factor correction capacitors shall be sized as recommended by the motor manufacturer to correct the motor power factor to over 90%. Motor power factor correction capacitor sizes shall not be larger than the maximum size recommended by the motor manufacturer. Enclosure type shall be NEMA 12. Capacitors shall be dry film type with fuses and discharge resistors.

P. Composite Factor: Each motor, 1 HP or larger, or motor driven equipment, 1 HP or larger shall have a composite power factor (PF) rating of ninety (90) percent to 100 percent when the driven equipment is operating at the design duty defined on the drawings. Power factor correction devices shall be provided to meet the stated criteria.

Q. Devices such as capacitors, or equipment such as solid-state power factor controllers, shall be provided as part of the motor or item of motor driven equipment when required for power factor correction. Devices shall be completely mounted and wired to the motor terminal except as follows:

1. For a motor or motor driven equipment requiring other than across-the-line starting, power factor (PF) correcting capacitors, or other equipment, shall be connected to motor terminals via a contactor (controller) with a 120-volt alternating current (VAC) coil. The 120-volt alternating current (VAC) coil shall be energized via an auxiliary contact on the contactor (controller) used to establish the "run" operating mode for the motor driven equipment.

2. For two (2) speed motors, power factor (PF) shall be corrected at each speed via separate groups of capacitors or other equipment for each speed. Each group of PF correcting components shall be connected to motor terminals via a separate contactor (controller) with a 120-volt alternating current (VAC) coil. Each 120-volt alternating current (VAC) coil shall be energized via an auxiliary contact on the contactor or controller used to establish "run" operations at each speed.

R. Locked rotor kVA shall not exceed NEMA Code Letter F for motors over 10 horsepower.

S. Motors shall have the following enclosure types in accordance with NEMA MG 1:

T. For clean dry indoor areas: open drip proof (ODP) fully-guarded

U. For outdoor locations: totally-enclosed fan-cooled for small and medium machines, weather protected type II for large machines

V. Explosion-proof machines shall be provided for hazardous areas classified in accordance with NFPA 70 (National Electrical Code). Explosion proof motors shall be NRTL-listed for the hazardous area classification.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Motors ½ HP and Larger: Three phase, unless otherwise indicated.

D. Motors Smaller Than ½ HP: Single phase.

E. Frequency Rating: 60 Hz.

F. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.05 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 EXECUTION

3.01 COMMISSIONING

A. Check operating motors for unusual conditions during normal operation. Coordinate with the commissioning of the equipment for which the motor is a part.

B. Report unusual conditions.

C. Correct deficiencies.

END OF SECTION

SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Flexible-hose expansion joints.
   2. Alignment guides and anchors.
   3. Pipe bends and loops.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor, alignment guide and expansion loop, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.03 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.05 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.02 EXPANSION JOINTS

A. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flex-Hose Co., Inc.
      b. Flexicraft Industries.
      c. Flex-Pression, Ltd.
      d. Metraflex, Inc.

2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder joint end connections.
   a. NPS 2and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg Fand 340 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged or weld end connections for NPS 2-1/2and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
   c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg Fatings.

2.03 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Adsco Manufacturing, LLC.
      b. Advanced Thermal Systems, Inc.
      c. Flex-Hose Co., Inc.
      d. Flexicraft Industries.
      e. Flex-Weld, Inc.
      f. Hyspan Precision Products, Inc.
      g. Metraflex, Inc.
      h. Piping Technology & Products, Inc.
      i. Senior Flexonics, Inc.; Pathway Division.
   2. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

B. Anchor Materials
   1. Steel Shapes and Plates: ASTM A 36/A 36M.
   2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
   3. Washers: ASTM F 844, steel, plain, flat washers.
   4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
      a. Stud: Threaded, zinc-coated carbon steel.
      b. Expansion Plug: Zinc-coated steel.
      c. Washer and Nut: Zinc-coated steel.
   5. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
      a. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
      b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
      c. Washer and Nut: Zinc-coated steel.
   6. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.
   7. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
      a. Properties: Nonstaining, noncorrosive, and nongaseous.

b. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.01 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

D. Install expansion joints as shown and at all building expansion and seismic joints. Refer to Architectural drawings for additional information.

E. Install expansion joints in accordance with manufacturer’s written instructions.

F. All piping shall be installed so that it will in no way be distorted or strained by expansion or contraction.

3.02 PIPE BEND AND LOOP INSTALLATION

A. Attach pipe bends and loops to anchors.
   1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.03 SWING CONNECTIONS

A. Install pipe loops as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.04 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install guides on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:
   1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.
   3. Grout.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.01 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

C. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube PVC sleeves in paragraph below may be prohibited by fire authorities having jurisdiction.

2.02 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements product by one of the following:
   1. Advance Products & Systems, Inc.
   2. CALPICO, Inc.
   3. Metraflex Company (The).
   4. Pipeline Seal and Insulator, Inc.
   5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Glass Reinforced Plastic.
   3. Connecting Bolts and Nuts: 316 Stainless Steel.

2.03 SLEEVE-SEAL FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
   1. Advance Products & Systems, Inc
   2. CALPICO, Inc
   3. GPT; an EnPro Industries company
   4. Metraflex Company (The)
   5. Proco Products, Inc
   6. Trumbull Industries

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.04 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 SLEEVE INSTALLATION

A. For all sleeves referenced below, install sleeves only for piping passing through the lower lever floor slab, insulated piping, or as required by UL details on the plans.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Firestopping."

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.04 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve-seals for the following piping-penetration applications:
   1. Exterior Concrete Walls above Grade:
      a. Piping Smaller Than NPS 6: Sleeve-seal system.
      b. Piping NPS 6 and Larger: Sleeve-seal system.
   2. Exterior Concrete Walls below Grade:
      a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.

1) Select sleeve-seal system size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
1) Select sleeve-seal system size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
1) Select sleeve-seal system size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.
1) Select sleeve-seal system size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
a. Piping Smaller Than NPS 6: Sleeve-seal system.
b. Piping NPS 6 and Larger: Sleeve-seal system.
5. Interior Partitions:
a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves
b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves

END OF SECTION

SECTION 23 05 18 - ESCUTCHEONS FOR HVAC PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.02 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange

PART 3 EXECUTION

3.01 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Insulated Piping: One-piece, stamped-steel type
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type
      e. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
      f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.

3.02 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

SECTION 23 05 19 - GAUGES FOR HVAC PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Liquid-in-glass thermometers.
   2. Thermowells
   3. Dial-type pressure gages
   4. Gage attachments
   5. Test plugs
   6. Test-plug kits
   7. Sight flow indicators

1.02 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.03 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Two gauges for each set of gauges with differing ranges.
   2. Two thermometers for each set of thermometers with differing ranges.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 PRODUCTS

2.01 METAL-CASE, INDUSTRIAL STYLE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Palmer - Wahl Instruments Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Standard: ASME B40.200.

C. Case: Cast aluminum, 7 inch nominal size unless otherwise indicated.

D. Case Form: Adjustable angle unless otherwise indicated.

E. Tube: Glass with magnifying lens and blue organic liquid.

F. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.

G. Window: Glass.

H. Stem: Aluminum and of length to suit installation.

I. Connector: 1-1/4” inches, with ASME B1.1 screw threads.

J. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.02 THERMOWELLS

A. Thermowells:
   1. Standard: ASME B40.200
   2. Description: Pressure-tight, socket type fitting made for insertion into pipe tee fitting.

3. Material for Use with Copper Tubing: CNR.
4. Material for Use wirth Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS ½, NPS ¾, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: ½, ¾ and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowells internal screw thread to size of thermometer connection.

B. Heat-transfer Medium: Mixture of graphite and glycerin.

2.03 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
1. Case: Sealed type; cast aluminum or drawn steel, 6-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS ¼ or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psa.
6. Pointer: Dark-colored metal.
7. Window: Glass.
8. Ring: Metal.
9. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.04 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS ¼ or NPS ½, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass pipe with NPS ¼ or NPS ½ pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS ¼ or NPS ½, ASME B1.20.1 pipe threads.

2.05 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flow Design, Inc.
2. Peterson Equipment Co., Inc.
3. Sisco Manufacturing Co.
4. Trerice, H. O. Co.
5. Watts Industries, Inc.; Water Products Div.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS ¼ or NPS ½, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.06 TEST-PLUG-KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flow Design, Inc.
   2. Peterson Equipment Co., Inc.
   3. Sisco Manufacturing Co.
   4. Trerice, H. O. Co.
   5. Watts Industries, Inc.; Water Products Div.

B. Low-Range Thermometer: Small, bimetallic insertion type with 1 to 2 inch diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

C. High-Range Thermometer: Small, bimetallic insertion type with 1 to 2 inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

D. Pressure Gage: Small, Bourdon-tube insertion type with 2 to 3 inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.07 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ARCHON Industries, Inc.
   2. Dwyer Instruments, Inc.
   3. Emerson Process Management; Rosemount Division
   4. Ernst Flow Industries
   5. John C. Ernst Co, Inc.
   6. KOBOLD Instruments, Inc. – USA
   7. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company
   8. Penberthy

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 125 psig

E. Minimum Temperature Rating: 200 deg. F

F. End connections for NPS 2 and Smaller: Threaded.

G. End connections for NPS 2-1/2 and Larger: Flanged.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
   1. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

B. Install thermowells with extension on insulated piping.

C. Fill thermowells with heat-transfer medium.

D. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

E. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most reliable position.

F. Install valve and snubber in piping for each pressure gage for fluids.

G. Install test plugs in piping tees.

H. Install combination test plugs on supply and return piping of all air handling unit water coils not otherwise provided with pressure and temperature gages.

I. Install flow indicators in piping systems in accessible positions for easy viewing.

J. Install thermometers in the following locations:
   1. Inlet and outlet of each hydronic zone
   2. Inlets and outlets of each hydronic boiler, chiller and cooling tower.
   3. Inlet and outlet of each hydronic coil in air handling units
   4. Two inlets and two outlets of each hydronic heat exchanger
   5. As indicated in details.
   6. Install pressure gages in the following locations:
   7. Discharge of each pressure reducing valves
   8. Inlets and outlets of each hydronic boiler and chiller.
   9. Suction and discharge of each pump
   10. As indicated in details.

K. Provide a single gauge with isolation valves when reading differential pressure across a piece of equipment.

3.02 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Condenser Water Piping 0 to 150 deg F.

C. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

3.03 PRESSURE GAGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 psi.

B. Scale Range for Condenser Water Piping 0 to 100 psi.

C. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi

3.04 CONNECTIONS

A. Install gages adjacent to machines and equipment to allow service and maintenance for gages, machines, and equipment.

END OF SECTION

SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Angle valves
   2. Globe valves
   3. Ball valves
   4. Butterfly valves
   5. Check valves
   6. Gate valves.

1.02 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.04 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

D. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged or welded-end valve bodies, comply with ANSI B16.10 “Face-to-Face and End-to-End Dimensions of Ferrous Valves”.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set gate and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
   4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
   1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   2. Butterfly Valves: With extended neck.

F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Grooved: With grooves according to AWWA C606.
   3. Solder Joint: With sockets according to ASME B16.18.
   4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

H. Flanges: Comply with ASTM A-216 for steel and ANSI B16.24 for bronze valves.

I. Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by Installer for installation requirements. Comply with ASME B31.1 for Power Piping.

J. Valve Design: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

K. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign materials in piping system can be expected to prevent tight shutoff of metal seated valves.

L. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

M. Fluid Control: Except as otherwise indicated, install ball valves to comply with ANSI B31.9. Where throttling is indicated or recognized as principal reason for valve, install globe valves.

2.02 GLOBE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Apollo Flow Controls; Conbraco Industries, Inc.
   2. Crane; Crane Energy Flow Solutions
   3. Hammond Valve
   4. KITZ Corporation
   5. Milwaukee Valve Company
   6. NIBCO INC.
   7. Stockham; Crane Energy Flow Solutions
   8. WATTS
   9. Velan, Inc
   10. Victaulic Company

11. Vogt

B. Bronze Globe Valves, Class 125:
   1. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron.

C. Iron Globe Valves, Class 125:
   1. Description:
      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.
      g. Operator: Handwheel or chainwheel.

2.03 BALL VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Apollo Flow Controls; Conbraco Industries, Inc.
   2. Crane; Crane Energy Flow Solutions
   3. Hammond Valve
   4. Jamesbury; Metso
   5. KITZ Corporation
   6. Milwaukee Valve Company
   7. NIBCO INC.
   8. WATTS

B. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
   1. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      d. Body Design: Two piece.
      e. Body Material: Bronze.
      f. Ends: Threaded or soldered.
      g. Seats: PTFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Full.
      k. Handle: Steel, coated lever.

2.04 BUTTERFLY VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Adams
   2. Apollo Flow Controls; Conbraco Industries, Inc.
   3. Bray Controls
   4. Crane; Crane Energy Flow Solutions
   5. Hammond Valve
   6. DeZURIK

7. KITZ Corporation
8. Milwaukee Valve Company
9. NIBCO INC.
10. Stockham; Crane Energy Flow Solutions
11. WATTS
12. Velan, Inc
13. Victaulic Company
14. Vogt

B. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
   1. Description:
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      e. Seat: EPDM.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Aluminum bronze.
      h. Valve Actuator Type:
         1) NPS 6 and Smaller: Lever type with locking trigger with ten (10) position notched quadrant.
         2) NPS 8 and Larger: Heavy duty gear operators.
         3) For valves used for throttling or balancing, include memory stops that are fully adjustable after insulation is applied.

C. Iron, Grooved-End Butterfly Valves, 175 CWP:
   1. Description:
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 175 psig.
      c. Body Material: Coated, ductile iron.
      d. Stem: Two-piece stainless steel.
      e. Disc: Coated, ductile iron.
      f. Seal: EPDM.
      g. Valve Actuator Type:
         1) NPS 6 and Smaller: Lever type with locking trigger with ten (10) position notched quadrant.
         2) NPS 8 and Larger: Heavy duty gear operators.
         3) For valves used for throttling or balancing, include memory stops that are fully adjustable after insulation is applied.

D. Steel, Single-Flange, High-Performance Butterfly Valves, Class 150:
   1. Description:
   2. Standard: MSS SP-68.
   3. CWP Rating: 285 psig at 100 deg F.
   4. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   5. Body Material: Carbon steel or stainless steel.
   6. Seat: Reinforced PTFE 15% glass.
   7. Stem: Stainless steel; dual or triple offset from seat plane.
   8. Disc: Stainless steel.
   9. Service: Bidirectional.
   10. Valve Actuator Type:
      a. NPS 6 and Smaller: Lever type with locking trigger with ten (10) position notched quadrant.
      b. NPS 8 and Larger: Heavy duty gear operators, adjustable memory stops.

c. For valves used for throttling or balancing, include memory stops that are fully adjustable after insulation is applied.

2.05 CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Apollo Flow Controls; Conbraco Industries, Inc.
2. Crane; Crane Energy Flow Solutions
3. Hammond Valve
4. KITZ Corporation
5. Milwaukee Valve Company
6. NIBCO INC.
7. Stockham; Crane Energy Flow Solutions
8. WATTS
9. Velan, Inc
10. Victaulic Company
11. Vogt

B. Bronze Swing Check Valves with Bronze Disc, Class 125:
1. Description:
a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

C. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 150:
1. Description:
a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

D. Iron Swing Check Valves with Metal Seats, Class 125:
1. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.

E. Iron, Grooved-End Swing Check Valves, 300 CWP:
1. Description:
a. CWP Rating: 300 psig.
b. Body Material: ASTM A 536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.06 GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Apollo Flow Controls; Conbraco Industries, Inc.

2. Crane; Crane Energy Flow Solutions
3. Hammond Valve
4. KITZ Corporation
5. Milwaukee Valve Company
6. NIBCO INC.
7. Stockham; Crane Energy Flow Solutions
8. WATTS
9. Velan, Inc
10. Victaulic Company
11. Vogt

B. Bronze Gate Valves, RS, Class 125:
   1. Description:
      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

C. Iron Gate Valves, OS&Y, Class 125:
   1. Description:
      a. Standard: MSS SP-70, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Disc: Solid wedge.
      g. Packing and Gasket: Asbestos free.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION

A. Valves shall be provided where indicated on the drawings and as herein specified.

B. Install shut-off valves in piping where shown and where listed below:
   1. To isolate all items of equipment.
   2. To isolate motorized flow control valves.
   3. To isolate branch lines and riser at mains.

C. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

D. Locate valves for easy access and provide separate support where necessary.
   1. Avoid installing valves in piping systems that are installed over casework, electrical panel boards, disconnects, transformers, generators, etc.

E. Install valves in horizontal piping with stem at or above center of pipe.

F. Install valves in position to allow for handwheel operation, full stem movement and stuffing maintenance.

G. Install chainwheels on operators for globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

H. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

I. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.03 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 SOCKET WELD CONNECTIONS

A. Make all socket weld connections in accordance with ASME Power Piping Code B31.1.

3.05 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.06 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.07 FIELD QUALITY CONTROL

A. After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.08 ADJUSTING AND CLEANING

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve with non-corrosive tag and Owner approved numbering scheme.

C. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

3.09 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Throttling Service: Globe valves.
   2. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
      b. NPS 2-1/2 and Larger: Iron, globe, center-guided, metal-seat check valves.
   3. Butterfly valves shall be used for shutoff only, do not use butterfly valves for flow balancing.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.10 CHILLED-WATER VALVE SCHEDULE

A. Ball Valves:
   1. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with full port and stainless-steel trim.
      a. Valves may be provided with solder-joint ends instead of threaded ends.

B. Butterfly Valves:
   1. Pipe NPS 2-1/2 and Larger:
      a. Ductile iron, single-flange butterfly valves with aluminum-bronze disc.
      b. Iron, grooved-end butterfly valves.
      c. Steel, single-flange, high-performance butterfly valves.

C. Check Valves:
   1. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125.
      a. May be provided with solder-joint ends instead of threaded ends.
   2. Pipe NPS 2-1/2 and Larger:
      a. Iron swing check valves with metal seats, Class 125.
      b. Iron, grooved-end swing check valves, 300 CWP.

3.11 HEATING-WATER VALVE SCHEDULE

A. Ball Valves:
   1. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with full port and stainless-steel trim.
      a. Valves may be provided with solder-joint ends instead of threaded ends.

B. Butterfly Valves:
   1. Pipe NPS 2-1/2 and Larger:
      a. Ductile iron, single-flange butterfly valves with aluminum-bronze disc.
      b. Iron, grooved-end butterfly valves.
      c. Steel, single-flange, high-performance butterfly valves.

C. Check Valves:
   1. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125.
      a. May be provided with solder-joint ends instead of threaded ends.
   2. Pipe NPS 2-1/2 and Larger:

a. Iron swing check valves with metal seats, Class 125.
b. Iron, grooved-end swing check valves, 300 CWP.

3.12 GLYCOL HEATING-WATER VALVE SCHEDULE

A. Ball Valves:
1. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with full port and stainless-steel trim.
a. Valves may be provided with solder-joint ends instead of threaded ends.

B. Butterfly Valves:
1. Pipe NPS 2-1/2 and Larger:
a. Ductile iron, single-flange butterfly valves with aluminum-bronze disc.
b. Steel, single-flange, high-performance butterfly valves.

C. Check Valves:
1. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125.
a. May be provided with solder-joint ends instead of threaded ends.
2. Pipe NPS 2-1/2 and Larger:
a. Iron swing check valves with metal seats, Class 125.
b. Iron, grooved-end swing check valves, 300 CWP.

3.13 LOW-PRESSURE STEAM AND TRAPPED CONDENSATE (15 PSIG OR LESS)

A. Globe Valves:
1. Pipe NPS 2 and Smaller: Bronze globe valves, Class 125, PTFE disc, and threaded ends.
2. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125, with flanged ends.

B. Ball Valves:
1. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with full port and stainless-steel trim, threaded ends.

C. Check Valves:
1. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125.
2. Pipe NPS 2-1/2 and Larger: Iron swing check valves with metal seats: Class 125.

D. Gate Valves:
1. Pipe NPS 2 and Smaller: Bronze gate valves, RS, Class 125.
2. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y, Class 125.

END OF SECTION

SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment supports.

1.02 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.03 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe stands. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.05 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.2, "Structural Welding Code--Aluminum."
   3. AWS D1.3, "Structural Welding Code--Sheet Steel."
   4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   5. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 PRODUCTS

2.01 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Bergen-Power Pipe Supports.
3. B-Line Systems, Inc.; a division of Cooper Industries.
4. Carpenter & Paterson, Inc.
5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co.
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
10. National Pipe Hanger Corporation.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.02 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.03 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
4. Power-Strut Div.; Tyco International, Ltd.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.04 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:
1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.05 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Masterset Fastening Systems, Inc.
      d. MKT Fastening, LLC.
      e. Powers Fasteners.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. B-Line Systems, Inc.; a division of Cooper Industries.
      b. Empire Industries, Inc.
      c. Hilti, Inc.
      d. ITW Ramset/Red Head.
      e. MKT Fastening, LLC.
      f. Powers Fasteners.

2.06 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
   1. Manufacturers:
      a. ERICO/Michigan Hanger Co.
      b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
   1. Manufacturers:
      a. MIRO Industries.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   1. Manufacturers:
      a. ERICO/Michigan Hanger Co.
      b. MIRO Industries.
      c. Portable Pipe Hangers.
   2. Base: Stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   1. Manufacturers:
      a. Portable Pipe Hangers.
   2. Bases: One or more plastic.
   3. Vertical Members: Two or more protective-coated-steel channels.
   4. Horizontal Member: Protective-coated-steel channel.
   5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.07 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.08 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Non-staining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi28-day compressive strength.

PART 3 EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
   8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
   9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
   10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
   11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
   12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
   3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
   4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
   5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. C-Clamps (MSS Type 23): For structural shapes.
   7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
   8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.02 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.06 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 23 05 48 - VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Freestanding and restrained spring isolators.
   5. Housed spring mounts.
   6. Elastomeric hangers.
   7. Spring hangers.
   8. Spring hangers with vertical-limit stops.
   9. Pipe riser resilient supports.
   10. Resilient pipe guides.
   11. Freestanding and restrained air-mounting system.
   12. Restrained vibration isolation roof-curb rails.
   13. Restraining braces and cables.
   14. Steel and inertia, vibration isolation equipment bases.

1.02 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type of component used.
      a. Annotate to indicate application of each product submitted and compliance with requirements.

B. Welding certificates.

C. Qualification Data: For professional engineer.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 PRODUCTS

2.01 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ace Mountings Co., Inc.

2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.
10. B-Line System, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inchthick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

F. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

G. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

H. Pipe Riser Resilient Support : All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

I. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.02 AIR-MOUNTING SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. California Dynamics Corporation.
2. Firestone Industrial Products Company.
3. Kinetics Noise Control.
4. Mason Industries.
5. Vibration Eliminator Co., Inc.

B. Air Mounts: Freestanding, single or multiple, compressed-air bellows.
1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig.
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch.

C. Restrained Air Mounts Housed compressed-air bellows.
1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch

2.03 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand wind forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
   1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with wind restraint.
      a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
      b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
      c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
      d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
      e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.04 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   2. California Dynamics Corporation.
   3. Isolation Technology, Inc.
   4. Kinetics Noise Control.
   5. Mason Industries.
   6. Vibration Eliminator Co., Inc.
   7. Vibration Isolation.
   8. Vibration Mountings & Controls, Inc.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
    a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
    a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.05 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

3.03 VIBRATION-CONTROL DEVICE INSTALLATION

A. Equipment Restraints:

B. Piping Restraints:
1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

G. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   3. Obtain Engineer’s approval before transmitting test loads to structure. Provide temporary load-spreading members.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Engineer.
   5. Test to 90 percent of rated proof load of device.
   6. Measure isolator restraint clearance.
   7. Measure isolator deflection.
   8. Verify snubber minimum clearances.
   9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
   11. Test and adjust air-mounting system controls and safeties.
   12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.05 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

F. Adjust snubbers according to manufacturer’s recommendations.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems.

3.07 HVAC VIBRATION-CONTROL DEVICE SCHEDULE

Vibration Isolation Schedule

Equipment	Isolation Type	Base Deflection	Type	Remarks
Fan in AHU's	Floor Spring Neoprene	1.5"	Base-Inertia Base	Thrust Restraints
LAB Vacuum Pumps	Floor Neoprene	0.4"	---	Under Skid
LAB Air Compressors	Floor Neoprene	0.4"	---	Under Skid
ATC Compressors	Floor Spring Neoprene	0.75"	Base-Inertia Base	----------
Domestic Water Pump	Floor Neoprene	0.4"	---	Under Skid
Suspended Fans	Hanger Spring Neoprene	1.5"	---	----------
Roof Mounted Fans	Roof Isolator	1.5"	---	----------
Base-Mounted Pumps	Floor Spring Neoprene	0.75"	Base-Inertia Base	----------
Floor Mounted Fans	Floor Spring Neoprene	1.5"	Base-Steel Frame	----------
In-Line Pumps	Flexible Neoprene	0.25"	---	----------

Cold Room Condenser	Floor Neoprene	---	---	----------
Pumps, Air Compressors, and Vacuum Pump Flexible Piping Connectors	Flexible Metallic Hoses	---	---	----------
Piping Hangers Within 50 Feet of Isolated Equipment	Spring Hangers	1.5"	---	----------
First Two (2) Pipe Hangers near Non-Isolated Equipment	Spring Hangers	1.0"	---	----------

END OF SECTION

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Valve tags.
   6. Warning tags.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.03 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.04 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. All major HVAC equipment, including air handlers, fans and pumps is properly identified with equipment identification, equipment controlled, electrical ratings and date of installation.
   2. For serviceable equipment such as VAV Boxes, AHU's, reheat coils, exhaust fans, pumps, etc. located above an acoustical lay-in ceiling, provide a clear adhesive label on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the ceiling access panel for that piece of equipment. The label shall indicate the equipment designation in black text with minimum 3/8" high lettering.
   3. For miscellaneous equipment requiring access such as valves, control dampers, access doors, etc., provide a ¾" colored adhesive button on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the engineer) or on the access panel for that piece of equipment. Button colors shall be as follows; HVAC - Blue.
   4. Material and Thickness: Equipment should be clearly identified with engraved phenolic nameplates securely fastened to the equipment with sheet metal screws. Equipment name/numbers shall be the same as shown in the contract documents and the BAS

Control drawings. Nameplates smaller than 4” by 2” shall only be allowed with approval from the designer.

5. Letter Color: Black
6. Background Color: White
7. Minimum Label Size: Shall be a minimum 4” by 2”.
8. Minimum Letter Size: ½” minimum.
9. Fasteners: Sheet metal screws.
10. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Identification shall be provided as follows: no further than 30 feet apart, at major changes in direction, at each valve or equipment, and on both sides of penetrations.

B. Pipe Labels: Provide stencil or strap-on identification indicating the system and the direction of flow.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inches high.

D. For insulated and un-insulated pipe systems, stencil sizes are as follows:

1. For pipes up to 1 inch, use ½ inch letters, 8” wide color band.
2. For pipes >1 inch to 2 inches, use ¾ inch letters, 8” wide color band.
3. For pipes >2 inches to 4 inches, use 1 ¼ inch letters, 12” wide color band.
4. For pipes >4 inches to 6 inches, use 1 ¼ inch letter, 12” wide color band.
5. For pipes above 6 inches, use 4 inch letters, 24” wide color band.

2.03 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware. Provide stencil or strap-on identification indicating the system and the direction of flow.

B. Maximum Temperature: Able to withstand temperatures up to 160 deg F

C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

D. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

E. Fasteners: Stainless-steel rivets or self-tapping screws.

F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1/2 inches high.

H. At each floor level and at roof level identify each exhaust air duct from safety cabinets and fume hoods by 2” tall painted black lettering identifying the room it originates from.

2.04 VALVE TAGS

A. Valve Tags: Stamped or engraved.
   1. Tag Material: Brass valve tags, minimum 1.5” diameter, minimum ¼: high lettering for the service matching the chart in paragraph b. above, minimum ½” high lettering indicating valve number, with brass or stainless steel chains for all isolation, branch and control valves.
   2. Valve tag chart to be included in the O&M manual.
   3. Valve tag chart to be mounted in all ME rooms in a frame with lexan cover.
   4. Include the tag numbers in the as-built drawings and record drawings.
   5. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inchbond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data and framed under a rigid plastic cover in each of the mechanical rooms and penthouse. Locate framed valve tag schedule adjacent to the door of the mechanical room and penthouse.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

C. Apply an adhesive backed tag to all ceiling mounted diffusers, grilles and registers that identify the airside equipment serving it, including EF, AHU, Terminal Unit, etc. Tag can be affixed to the ceiling grid adjacent to the diffuser, grille or register.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 30 feet along each run in concealed and un-concealed areas.
   7. On piping above removable acoustical ceilings.
   8. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.
   9. For insulated and un-insulated pipe systems, stencil sizes are as follow:
      a. For pipes up to 1 inch, use ½ inch letters, 8” wide color band.

b. For pipes >1 inch to 2 inches, use ¾ inch letters, 8” wide color band.
c. For pipes >2 inches to 4 inches, use 1 ¼ inch letters, 12: wide color band.
d. For pipes >4 inches to 6 inches, use 1 ¼ inch letters, 12” wide color band.
e. For pipes above 6 inches, use 4 inch letters, 24” wide color band.

3.04 DUCT LABEL INSTALLATION

A. Install duct labels with permanent adhesive on air ducts.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 10 feet in each space where ducts are exposed or concealed by removable ceiling system.

C. At each floor level and at roof level identify each exhaust air duct from safety cabinets and fume hoods by 2” tall painted black lettering identifying the room it originates from.

3.05 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
a. Chilled Water: 1-1/2 inches, round.
b. Heating Water: 1-1/2 inches round.
c. Heat Recovery Water: 1-1/2 inches round.
d. Refrigerant: 1-1/2 inches round.
e. Gas: 1-1/2 inches, round.
2. Valve-Tag Color:
a. Chilled Water: Natural.
b. Heating Water: Natural.
c. Heat Recovery Water: Natural.
d. Refrigerant: Natural.
e. Gas: Natural.
3. Letter Color:
a. Chilled Water: Black.
b. Heating Water: Black.
c. Heat Recovery Water: Black.
d. Refrigerant: Black.
e. Gas: Black

3.06 CEILING-TAG INSTALLATION

A. For serviceable equipment such as VAV Boxes, AHU’s, reheat coils, exhaust fans, pumps, etc. located above an acoustical lay-in ceiling, provide a clear adhesive label on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the ceiling access panel for that piece of equipment. The label shall indicate the equipment designation in black text with minimum 3/8” high lettering.

B. For miscellaneous equipment requiring access such as valves, control dampers, access doors, multichannel transformers, BAS Network switches, etc., provide a ¾” colored adhesive button on the ceiling grid directly below the equipment. For equipment located above a drywall or hard ceiling, provide the label on an adjacent vertical surface (location approved by the designer) or on the access panel for that piece of equipment. Button colors shall be as follows; Plumbing-Green, HVAC-Blue, Fire Sprinkler-Red.

3.07 COLOR CODING

A. Completely paint piping systems in mechanical rooms and the penthouse with the applicable colors listed below.

B. Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.

C. The system colors and identifications are as follows:

Pipe/Duct System	Pipe/Duct Color	Identification	Label Color	Lettering Color
Chilled Water Supply	Dark Blue	CHWS	Green	White
Chilled Water Return	Dark Blue	CHWR	Green	White
Refrigerant	Black	REFRIG	Yellow	Black
Heating Water Supply	Dark Orange	HHWS	Green	White
Heating Water Return	Dark Orange	HHWR	Green	White
Controls Conduit	Yellow (2)			
Supply Ductwork	White (1)	SUPPLY AIR	Green	White
Return Ductwork	White (1)	RETURN AIR	Green	White
Relief Ductwork	White (1)	RELIEF AIR	Blue	White
Outside Air Ductwork	White (1)	OUTSIDE AIR	Blue	White
Exhaust Ductwork	Same as surrounding area	EXHAUST	Yellow	Black

Notes:

(1) White jacketing applies to insulated, non-concealed ductwork.

(2) Controls conduit shall be specified as factory painted.

END OF SECTION

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Testing, Adjusting, and Balancing of Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
      a. Constant-flow hydronic systems.
      b. Variable-flow hydronic systems.
   3. Testing, adjusting, and balancing of steam and condensate piping systems.
   4. Testing, adjusting, and balancing of equipment.
   5. Procedures for exhaust hoods.
   6. Duct leakage tests verification.
   7. Pipe leakage tests verification.
   8. HVAC-control system verification.
   9. Indoor-air quality measuring.
   10. Test opening force on doors to comply with code requirements.

1.02 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

E. TDH: Total dynamic head.

F. UFAD: Underfloor air distribution.

1.03 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
   1. Minimum Agenda Items:
      a. The Contract Documents examination report.
      b. The TAB plan.
      c. Needs for coordination and cooperation of trades and subcontractors.
      d. Proposed procedures for documentation and communication flow.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: The TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report as specified in Part 3.

C. Strategies and Procedures Plan as specified in "Preparation" Article.

D. System Readiness Checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.05 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC or NEBB:
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

D. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

E. TAB balance reports must be sealed as accurate by a professional engineer licensed in the State of North Carolina.

1.06 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, BAS provider, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Coordinate efforts with the project Commissioning Agent. Refer to commissioning specifications for additional information.

C. Provide seven days' advance notice for each test. Include scheduled test dates and times.

D. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.07 FIELD CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Final Acceptance. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.08 WARRANTY

A. Performance Warranty:
   1. If AABC standards are used, provide a warranty on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
   2. If NEBB standards are used, provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.

B. Warranty includes the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine AHU, boiler and terminal unit by-pass piping used for water treatment flushing. Verify that valves in flushing bypass piping are fully closed.

M. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine system pumps to ensure absence of entrained air in the suction piping.

P. Examine operating safety interlocks and controls on HVAC equipment.

Q. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes the following:
   1. Equipment and systems to be tested.
   2. Strategies and step-by-step procedures for balancing the systems.
   3. Instrumentation to be used.
   4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
   1. Airside:
      a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
      b. Duct systems are complete with terminals installed.
      c. Volume, smoke, and fire dampers are open and functional.
      d. Clean filters are installed.
      e. Fans are operating, free of vibration, and rotating in correct direction.
      f. Variable-frequency controllers' startup is complete and safeties are verified.
      g. Automatic temperature-control systems are operational.
      h. Ceilings are installed.
      i. Windows and doors are installed.
      j. Suitable access to balancing devices and equipment is provided.
   2. Hydronics:
      a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
      b. Piping is complete with terminals installed.
      c. Water treatment is complete.
      d. Systems are flushed, filled, and air purged.
      e. Strainers are pulled and cleaned.
      f. Control valves are functioning in accordance with the sequence of operation.
      g. Shutoff and balance valves have been verified to be 100 percent open.
      h. Pumps are started and proper rotation is verified.
      i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
      j. Variable-frequency controllers' startup is complete and safeties are verified.
      k. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
   2. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 23 07 00 "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
   1. Motors.
   2. Pumps.
   3. Fans and ventilators.
   4. Air curtains.
   5. Terminal units.
   6. Boilers.
   7. Radiant heaters.
   8. Unit heaters.
   9. Solar collectors.
   10. Heat exchangers.
   11. Condensing units.
   12. Condensers.
   13. Energy-recovery units.
   14. Air-handling units.
   15. Heating and ventilating units.
   16. Rooftop air-conditioning units.
   17. Heating-only makeup air units.
   18. Dedicated outdoor-air units.
   19. Packaged air conditioners.
   20. Self-contained air conditioners.
   21. Split-system air conditioners.
   22. Coils.
   23. Fan coil units.
   24. Humidifiers.
   25. Fume Hoods.
   26. Lab Exhaust System.

3.05 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

3.06 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
2. Measure fan static pressures as follows:
    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.
3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.07 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:
1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.

3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
    c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
    d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
    a. Balance the return-air ducts and inlets.
    b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor. Controls contractor to update as-built documents.
9. Verify final system conditions as follows:
    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.

c. Re-measure final fan operating data, speed, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.08 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
1. Check expansion tank for proper setting.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
5. Verify that motor controllers are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
1. Check settings and operation of each safety valve. Record settings.

3.09 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design flow.
1. Measure total water flow.
a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
2. Measure pump TDH as follows:
a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:
1. Verify that the pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:
1. Adjust pumps to deliver total design flow.
a. Measure total water flow.
1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
b. Measure pump TDH as follows:
1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
2. Adjust flow-measuring devices installed in mains and branches to design water flows.
a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
    a. Measure differential pressure and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
    a. Measure and balance coils by either coil pressure drop or temperature method.
    b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
6. Prior to verifying final system conditions, determine the system pressure-differential set point(s). Controls contractor to update as-built documents.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:
    a. Re-measure and confirm that total flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

D. For systems with flow diversity:
1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.
    a. Measure total water flow.
        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
    b. Measure pump TDH as follows:
        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gauge heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
    c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
4. Adjust flow-measuring devices installed in mains and branches to design water flows.
    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.

c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure, and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

3.11 PROCEDURES FOR STEAM AND CONDENSATE SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.12 PROCEDURES FOR WATER-TO-WATER HEAT EXCHANGERS

A. Adjust and record water flow to within specified tolerances.

B. Measure and record inlet and outlet water temperatures.

C. Measure and record pressure drop.

D. Check and record settings and operation of safety and relief valves.

3.13 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Phase and hertz.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.

7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.14 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.15 PROCEDURES FOR AIR-COOLED CONDENSERS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of fan(s) and motor(s).

3.16 PROCEDURES FOR BOILERS

A. Hydronic Boilers:
1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Measure and record pressure drop.
4. Record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h of heating output.
6. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
8. Fan, motor, and motor controller operating data.

3.17 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic coil:
1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:
1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Air pressure drop.
5. Voltage and amperage input of each phase at full load.
6. Calculated kilowatt at full load.
7. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Entering and leaving refrigerant pressure and temperatures.

3.18 PROCEDURES FOR EXHAUST HOODS

A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.

B. Makeup Air: Systems supplying source of makeup air to hoods shall be in operation during testing and balancing of exhaust hoods.
   1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
   2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.

C. Rooms with Multiple Hoods: Test each hood separately, one at a time, and repeat tests with all hoods intended to operate simultaneously by design.

D. Canopy Hoods: Measure and record the following:
   1. Pressure drop across hood.
   2. Airflow by duct traverse where duct distribution will allow accurate measurement and calculate hood average face velocity.
   3. Measure velocity across hood face and calculate hood airflow.
      a. Clearly indicate the direction of flow at each point of measurement.
      b. Measure velocity across opening on not less than 12-inch centers. Record velocity at each measurement and calculate average velocity.
   4. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.

E. Laboratory Fume Hoods: Measure and record the following:
   1. Pressure drop across hood.
   2. Airflow by duct traverse where duct distribution will allow accurate measurement and calculate hood average face velocity. If hood is connected to exhaust duct distribution through an exhaust device with integral airflow measurement, that reading may be used in lieu of a duct traverse.
   3. Face velocity across open hood face and calculate hood airflow.
      a. Clearly indicate the direction of flow at each point of measurement.
      b. Measure velocity across opening on not less than 6-inch centers. Record velocity at each measurement and calculate average velocity.
   4. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.
   5. ASHRAE 110 Testing: With room and laboratory fume hood operating at design conditions, perform an "as-installed" performance test of the laboratory fume hood in accordance with ASHRAE 110. Test each laboratory fume hood and document the test results.

F. AHJ Tests: Conduct additional tests required by authorities having jurisdiction.

3.19 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.20 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.21 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
   1. Verify HVAC control system is operating within the design limitations.
   2. Confirm that the sequences of operation are in compliance with Contract Documents.
   3. Verify that controllers are calibrated and function as intended.
   4. Verify that controller set points are as indicated.
   5. Verify the operation of lockout or interlock systems.
   6. Verify the operation of valve and damper actuators.
   7. Verify that controlled devices are properly installed and connected to correct controller.
   8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
   9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.22 INDOOR-AIR QUALITY TESTING

A. After construction is complete (including air balancing and final cleaning) and prior to occupancy, with the HVAC systems operating at indicated conditions conduct baseline pre-occupancy indoor air quality testing in accordance with the "Green Globes® for New Construction 2021 Technical Reference Manual", Credit 6.2.2, using testing protocols consistent with:
   1. U.S. EPA’s Compendium of Methods for the Determination of Toxic Organic Pollutants in Ambient Air.
   2. EPA TO-1, TO-11, TO-17.
   3. ASTM D 5197-09e1 Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology).

B. The test protocols shall be in accordance with the following:
   1. All measurements shall be conducted prior to occupancy, but during normal occupied hours, and with the building ventilation system starting at the normal daily start time and operated at the minimum outside air flow rate for the occupied mode throughout the duration of the air testing.
   2. The building shall have all interior finishes installed, including but not limited to millwork, doors, paint, carpet and acoustic tiles. Non-fixed furnishings such as workstations and partitions are encouraged, but not required, to be in place for the testing.
   3. Air sampling and monitoring shall be at a height of 3 feet and 6 feet from the floor to represent the breathing zone of occupants and at least 3 feet away from walls and ventilation supply.
   4. The test protocols shall be documented to show that appropriate sampling methods and times were used.
   5. The number of sampling locations shall be as follows for each portion of the building served by a separate ventilation system
      a. At least one per contiguous floor; and
      b. At least one per 10,000 SF of floor area.
   6. The sampling points shall include areas presumed to have the greatest source strength with the least ventilation.

C. For each location, measure, record and demonstrate that the maximum contaminant concentrations listed in "Green Globes® for New Construction 2021 Technical Reference Manual" Table 11.2.2.1.1 are not exceeded.

D. Submit a copy of the proposed IAQ testing procedures, actual testing locations, and testing results.

3.23 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
   2. Air Outlets and Inlets: Plus or minus 10 percent.
   3. Heating-Water Flow Rate: Plus or minus 10 percent.
   4. Chilled-Water Flow Rate: Plus 10 percent or minus 0 percent.
   5. Condenser-Water Flow Rate: Plus 10 percent or minus 0 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.24 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.25 FINAL REPORT

A. General: Prepare a certified written report in hard copy and .PDF format; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents, including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Variable-frequency controller and inlet vane settings for variable-air-volume systems.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.
16. Test conditions for pump performance forms, including the following:
    a. Variable-frequency controller settings for variable-flow hydronic systems.
    b. Settings for pressure controller(s).
    c. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.
2. Motor Data:
    a. Motor make, and frame type and size.
    b. Horsepower and speed.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.

F. Apparatus-Coil Test Reports:
1. Coil Data:
a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
a. System fan and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

I. Air-Terminal-Device Reports:
1. Unit Data:
a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..
2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
1. Unit Data:
a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.

e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.
3. Pump Test Data: (Indicated and Actual Values):
   a. Voltage at each connection.
   b. Amperage for each phase.
   c. Water flow rate in gpm.
4. Water Test Data: (Indicated and Actual Values):
   a. Entering-water temperature in deg F.
   b. Leaving-water temperature in deg F.
   c. Water temperature differential in deg F.
   d. Entering-water pressure in feet of head or psig.
   e. Leaving-water pressure in feet of head or psig.
   f. Water pressure differential in feet of head or psig.
   g. Water flow rate in gpm.
   h. Bleed water flow rate in gpm.
5. Air Data: (Indicated and Actual Values):
   a. Duct airflow rate in cfm.
   b. Inlet-duct static pressure in inches wg.
   c. Outlet-duct static pressure in inches wg.
   d. Average entering-air, wet-bulb temperature in deg F.
   e. Average leaving-air, wet-bulb temperature in deg F.
   f. Ambient wet-bulb temperature in deg F.

K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:
1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model number and serial number.
   f. Water flow rate in gpm.
   g. Water pressure differential in feet of head or psig.
   h. Required net positive suction head in feet of head or psig.
   i. Pump speed.
   j. Impeller diameter in inches.
   k. Motor make and frame size.
   l. Motor horsepower and rpm.
   m. Voltage at each connection.
   n. Amperage for each phase.
   o. Full-load amperage and service factor.
   p. Seal type.
2. Test Data (Indicated and Actual Values):
   a. Static head in feet of head or psig.
   b. Pump shutoff pressure in feet of head or psig.
   c. Actual impeller size in inches.
   d. Full-open flow rate in gpm.
   e. Full-open pressure in feet of head or psig.

f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

L. Air-to-Air Heat-Recovery Unit Reports:
1. Unit Data:
a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
2. Motor Data:
a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
3. If fans are an integral part of the unit, include the following for each fan:
a. Make and type.
b. Arrangement and size.
c. Sheave make, size in inches, and bore.
d. Sheave dimensions, center-to-center, and amount of adjustments in inches.
4. Test Data (Indicated and Actual Values):
a. Total exhaust airflow rate in cfm.
b. Purge exhaust airflow rate in cfm.
c. Outside airflow rate in cfm.
d. Total exhaust fan static pressure in inches wg.
e. Total outside-air fan static pressure in inches wg.
f. Pressure drop on each side of recovery wheel in inches wg.
g. Exhaust air temperature entering in deg F.
h. Exhaust air temperature leaving in deg F.
i. Outside-air temperature entering in deg F.
j. Outside-air temperature leaving in deg F.
k. Calculate sensible and total heat capacity of each airstream in MBh.

M. Vibration Measurement Reports:
1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
6. Calculate isolator efficiency using measurements taken.
7. Description of predominant vibration source.

N. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:
1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.

4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

O. Indoor-Air Quality Measurement Reports for Each HVAC System:
1. HVAC system designation.
2. Date and time of test.
3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
4. Room number or similar description for each location.
5. Measurements at each location.
6. Observed deficiencies.

P. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.26 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of the Engineer, Owner’s representative or Commissioning authority.

B. Engineer, Owner’s representative or Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.27 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 07 00 - HVAC INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes insulation for the following HVAC services:
   1. HVAC piping.
   2. HVAC equipment.
   3. HVAC duct services.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Sustainable Design Submittals:
   1. Product Data: For adhesives and sealants, documentation including printed statement of VOC content.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties.
   6. Detail removable insulation at equipment connections.
   7. Detail application of field-applied jackets.
   8. Detail application at linkages of control devices.
   9. Detail field application for each equipment type.

D. Samples:
   1. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by the manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.07 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.02 INSULATION MATERIALS

A. Comply with requirements in PART 3 - EXECUTION articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA, Inc.
      b. Airex Manufacturing
      c. Armacell LLC
      d. K-Flex USA
   2. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   3. Thermal conductivity (k-value) at 75 deg F shall be 0.28 Btu x in./h x sq. ft. x deg F or less.

G. Mineral-Fiber Blanket Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville; a Berkshire Hathaway company
      c. Knauf Insulation
      d. Manson Insulation Inc.
      e. Owens Corning
   2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I without factory-applied jacket, Type II with factory-applied vinyl jacket or Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   3. Compressed thermal conductivity (k-value) at 75 deg F shall be 0.27 Btu x in./h x sq. ft. x deg F or less. Minimum installed R-Value of 3.0 (hr•ft2•°F)/Btu per inch thickness.

H. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville; a Berkshire Hathaway company

c. Knauf Insulation
d. Manson Insulation Inc.
e. Owens Corning

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Thermal conductivity (k-value) at 75 deg F shall be 0.23 Btu x in./h x sq. ft. x deg F or less.

I. Mineral-Fiber, Pipe and Tank Insulation:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company
b. Knauf Insulation
c. Manson Insulation Inc.
d. Owens Corning
2. Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 75 deg F is 0.24 Btu x in./h x sq. ft. x deg F or less.

J. Mineral-Fiber Board Insulation:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. CertainTeed Corporation
b. Johns Manville; a Berkshire Hathaway company
c. Knauf Insulation
d. Manson Insulation Inc.
e. Thermafiber, Inc.; an Owens Corning company
2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Thermal conductivity (k-value) at 75 deg F shall be 0.23 Btu x in./h x sq. ft. x deg F or less. Minimum R-Value of 4.3 (hr•ft2•°F)/Btu per inch thickness.

K. Polyisocyanurate:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Dow
b. ITW Insulation Systems; Illinois Tool Works, Inc.
c. Johns Manville; a Berkshire Hathaway company
2. Faced, rigid cellular polyisocyanurate sheathing material intended for use as thermal duct and pipe insulation.
3. Comply with ASTM C1289 Type 1, Class 1 or ASTM C591, Grade 2, Type IV. The compressive resistance shall not be less than 16.0 psi and a minimum installed R-Value of 5.0 (hr•ft2•°F)/Btu per inch thickness.
4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
5. Duct Applications: FSK.

2.03 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M
b. CertainTeed Corporation
c. Johns Manville; a Berkshire Hathaway company
d. Nelson Firestop; a brand of Emerson Industrial Automation
e. Thermal Ceramics
f. Unifrax Corporation

2.04 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.05 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. For indoor applications, use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aeroflex USA, Inc.
2. Armacell LLC
3. Childers Brand; H. B. Fuller Construction Products
4. Dow Corning Corporatio
5. Eagle Bridges - Marathon Industries
6. Foster Brand; H. B. Fuller Construction Products.
7. Johns Manville; a Berkshire Hathaway company
8. K-Flex USA
9. P.I.C. Plastics, Inc.
10. Mon-Eco Industries, Inc.
11. Speedline Corporation
12. Vimasco Corporation.

D. Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

E. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

G. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

H. PVC Jacket Adhesive: Compatible with PVC jacket.

2.06 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. For indoor applications, use mastics that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Childers Brand; H. B. Fuller Construction Products
2. Eagle Bridges - Marathon Industries

3. Foster Brand; H. B. Fuller Construction Products.
4. Knauf Insulation
5. Mon-Eco Industries, Inc.
6. Vimasco Corporation

D. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.07 LAGGING ADHESIVES

A. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Childers Brand; H. B. Fuller Construction Products
2. Foster Brand; H. B. Fuller Construction Products.
3. Vimasco Corporation

C. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.08 SEALANTS

A. Use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24)

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Childers Brand; H. B. Fuller Construction Products
2. Eagle Bridges - Marathon Industries
3. Foster Brand; H. B. Fuller Construction Products.
4. Knauf Insulation
5. Mon-Eco Industries, Inc.
6. Pittsburgh Corning Corporation
7. Vimasco Corporation

C. Polyisocyanurate Joint Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.

D. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

E. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.09 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Alpha Associates, Inc

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 30 mils thick; roll stock ready for shop or field cutting and forming.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company
b. P.I.C. Plastics, Inc.
c. Proto Corporation
d. Speedline Corporation
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Architect.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, and mechanical joints.
b. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.
2. Aluminum Jacket: Comply with ASTM B 209, ASTM C 1729, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
a. Factory cut and rolled to size.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:
1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.

4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 58 ounces force/inch in width.
   4. Elongation: 8.5 percent.
   5. Tensile Strength: 23 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.
   2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Aluminum, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Aluminum, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.14 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
1. For exterior, above-grade piping: Before insulating, apply a corrosion coating to insulated surfaces as follows:

a. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing any heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, duct and piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials clean and dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions unless otherwise directed by manufacturer’s installation instructions.

F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations unless otherwise directed by manufacturer’s installation instructions.
2. Seal penetrations through fire-rated assemblies.

3.05 GENERAL INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket (except for flexible elastomeric), install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Insulate reheat coils, including exposed tubing U-bends, on concealed air terminal units.

E. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insu-

lating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.06 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Insulation Installation for Tanks and Vessels:
   1. Install insulation over entire surface of tanks and vessels.
   2. Apply 50 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   3. Seal longitudinal seams and end joints.

F. Insulation Installation on Pumps:
   1. Fabricate metal boxes lined with elastomeric insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   2. Fabricate boxes from aluminum, at least 0.040 inch thick.
   3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

G. Insulation Installation on HVAC Ducts
   1. Install insulation over entire surface of ducts.
   2. Apply 50 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   3. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

H. Provide latex-based, UV resistant protective coating for outdoor applications.

3.07 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Insulation Installation for Tanks and Vessels:
1. Secure insulation with adhesive and anchor pins and speed washers.
2. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
3. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
4. Protect exposed corners with secured corner angles.
5. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
6. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
7. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insula-

tion. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

8. Stagger joints between insulation layers at least 3 inches.
9. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
10. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
11. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

F. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
   3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
      a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      d. Do not overcompress insulation during installation.
      e. Impale insulation over pins and attach speed washers.
      f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
   4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
      a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
      b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
   5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
   6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

G. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.08 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

E. Insulation Installation on Ducts and Plenums:
1. Install insulation over entire surface of ducts.
2. Apply minimum 50 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
3. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.09 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies.

3.11 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.12 FIELD QUALITY CONTROL

A. If workmanship is of questionable quality, the contractor shall perform tests and inspections as directed by the Architect.

B. Tests and Inspections:
   1. Inspect field insulated equipment, ductwork, pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.

C. All insulation applications will be considered defective Work if sample inspection reveals non-compliance with requirements.

3.13 INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Ducts shall be externally insulated only. Internally lined ductwork shall not be used except for air transfer ducts. Provide anti-microbial coatings on the inside surface of all internally lined transfer ducts.

C. HVAC Piping Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

D. HVAC Equipment Items Not Insulated: Unless otherwise indicated, do not install insulation on equipment that is factory insulated.

E. HVAC Ducts Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Fibrous-glass ducts.
   2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   3. Factory-insulated flexible ducts.
   4. Factory-insulated plenums and casings.
   5. Flexible connectors.
   6. Vibration-control devices.
   7. Factory-insulated access panels and doors.
   8. Return and exhaust air ducts within shafts and chases located interior to the building.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 3/4 inch thick.

B. Chilled Water, above 40 Deg F:
   1. NPS 6 and Smaller: Insulation shall be the following:
      a. Polyisocyanurate: 1-1/2 inches thick.

C. Heating-Hot-Water Supply and Return:
   1. NPS 1-1/4 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
   2. NPS 1-1/2 and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

D. Steam, Steam Relief and Steam Condensate, 250 Deg F and Below (0-15 psig):
   1. NPS 3 and Smaller: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.

E. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1 inch thick.

F. Glycol Heat-Recovery Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Polyisocyanurate: 1-1/2 inches thick.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Glycol Heat-Recovery Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 2 inches thick.

3.16 EQUIPMENT INSULATION SCHEDULE

A. Chilled-water pump insulation shall be the following:
1. Flexible Elastomeric: 2 inches thick.

B. Chilled-water expansion/compression tank insulation shall be the following:
1. Flexible Elastomeric: 1 inch thick.

C. Heating-hot-water expansion/compression tank insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inch thick and 3-lb/cu. ft. nominal density.
2. Mineral-Fiber Pipe and Tank: 2 inch thick.

D. Heat-recovery expansion/compression tank insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick.

E. Heat-recovery air-separator insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
2. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.17 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply-air and outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2-1/5 inches thick and 0.75-lb/cu. ft. nominal density.

B. Concealed, return-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

C. Concealed, exhaust-air heat recovery duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, supply-air and outdoor-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2-1/5 inches thick and 0.75-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

F. Concealed, relief-air and exhaust-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
2. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

G. Concealed, supply-air devices shall be the following:
1. Mineral-Fiber Blanket: 1 inch thick and 1-lb/cu. ft. nominal density.

H. Exposed, supply-air and outdoor-air duct insulation shall be the following (unfinished/unoccupied areas, i.e., penthouse):

1. Within Eight (8) Feet of Finished Floor: Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.
2. Eight (8) Feet Above Finished Floor and Higher: Mineral-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

I. Exposed, return-air duct insulation shall be the following (unfinished/unoccupied areas, i.e., penthouse):
1. Within Eight (8) Feet of Finished Floor: Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
2. Eight (8) Feet Above Finished Floor and Higher: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

J. Exposed, exhaust-air heat recovery duct insulation shall be the following (unfinished/unoccupied areas, i.e., penthouse):
1. Within Eight (8) Feet of Finished Floor: Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
2. Eight (8) Feet Above Finished Floor and Higher: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

K. Exposed, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following (unfinished/unoccupied areas, i.e., penthouse):
1. Within Eight (8) Feet of Finished Floor: Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
2. Eight (8) Feet Above Finished Floor and Higher: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

L. Exposed, supply-air and outdoor-air plenum insulation shall be the following (unfinished/unoccupied areas, i.e., penthouse):
1. Within Eight (8) Feet of Finished Floor: Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.
2. Eight (8) Feet Above Finished Floor and Higher: Mineral-Fiber Blanket: 2.2 inches thick and 0.75-lb/cu. ft. nominal density.

M. Exposed, relief-air and exhaust-air plenum insulation shall be the following (unfinished/unoccupied areas, i.e., penthouse):
1. Within Eight (8) Feet of Finished Floor: Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
2. Eight (8) Feet Above Finished Floor and Higher: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

3.18 ABOVEGROUND, OUTDOOR DUCT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Exposed, exhaust-air heat recovery duct insulation shall be the following:
1. Polyisocyanurate Sheathing: 2 inches.

3.19 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed:
1. None.

C. Piping, Exposed in Finished and/or Occupied Areas:
1. PVC, Color-Coded by System: minimum 20 mils thick. Color by Owner or Architect.

D. Equipment, Concealed:
1. None.

E. Equipment, Exposed:
1. None.

F. Ducts and Plenums, Concealed:
   1. None.

G. Ducts and Plenums, Exposed:
   1. Woven Glass-Fiber Fabric on ducts and plenums within eight (8) feet of finished floor in unfinished/unoccupied areas, i.e., penthouse.

3.20 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Exposed:
   1. Aluminum, Stucco Embossed with Z-Shaped Locking Seam. Minimum jacket thickness shall be based on the outer insulation diameter:
      a. 8-inches and smaller: 0.024 inches thick.
      b. 10-inches to 36-inches: 0.032 inches thick.

C. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Stucco Embossed: 0.040 inch thick.

END OF SECTION

SECTION 23 08 13 - COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The purpose of this section is to specify the Division 23 contractor responsibilities in the commissioning (Cx) process.

B. Commissioning requires the participation of the Division 23 contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019113, General Commissioning Requirements. The Division 23 contractor shall be familiar with all parts of Section 019113 and the Cx Plan issued by the Commissioning Authority (CxA) and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

C. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment

1. Heating, ventilating and air conditioning (HVAC) systems and controls (1.5.1A.1A)
    a. VAV air handling unit
    b. Dedicated outdoor air units
    c. Energy recovery coils/systems
    d. VAV terminal boxes
    e. Laboratory supply/exhaust air valves
    f. Laboratory exhaust fans
    g. General Exhaust fans
    h. Ductless split system AC units
    i. Hot water unit heater
    j. Building automation system (control and interface associated with commissioned systems)

1.3 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process, as specifically related to the mechanical systems, are provided in this section.

B. Refer to Section 019113 and the Cx Plan for all typical commissioning process requirements for each team member.

C. Each Contractor and subcontractor shall review this Section and shall include in their bids cost for carrying out the work described, as it applies to each Division and Section of these specifications, individually and collectively.

D. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 23 are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

1. Include the cost of commissioning work in the contract price.

2. Attend a commissioning kick-off meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process, as indicated in specification section 019113.
3. Contractors shall provide the CxA with cut sheets and shop drawing submittals of commissioned equipment to the CxA.
4. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of Pre-Functional Checklists (PFC) and Functional Performance Testing (FPT) procedures.
    a. Typically, this will include detailed manufacturer installation and startup, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, startup, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
    b. The CxA may request further documentation necessary for the commissioning process.
5. Provide a copy of the equipment submittals of commissioned equipment, through normal channels, to the CxA for review and comment.
6. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
7. Provide assistance to the CxA in preparing the specific FPT procedures as specified in theCx Plan (prepared by the CxA), Section 019113 and this section. Contractor(s) shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
8. Develop a full startup and initial checkout plan using manufacturer’s startup procedures and the PFCs for all commissioned equipment. Submit manufacturer’s detailed startup procedures and the full startup plan and procedures and other requested equipment documentation to CxA for review and comment. Refer to Section 019113 for further details on startup plan preparation.
9. During the startup and initial checkout process, execute the mechanical-related portions of the PFCs for all commissioned equipment.
10. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
11. Address current A/E punch list items before FPT. Air and water TAB shall be completed with discrepancies and problems remedied. The TAB Report is to be reviewed and approved by the Engineer of Record prior to beginning TAB verification and FPT.
12. Provide skilled technicians to execute starting of equipment and to execute the FPTs. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
13. Perform FPTs under the direction of the CxA for specified equipment in the Cx Plan, Section 019113 and this Section. Assist the CxA in interpreting the monitoring data, as necessary.
14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, Construction Manager/General Contractor (CM/GC) and A/E and retest the equipment.
15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

16. During construction, maintain as-built/record red-line drawings and CAD drawings and provide final record drawings for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).
17. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
18. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.
2. Correct deficiencies and make necessary adjustments to O&M manuals and record drawings for applicable issues identified in any seasonal testing.

A. Mechanical Contractor

Construction and Acceptance Phases

1. Provide startup for all HVAC equipment, except for the building automation control system.
2. Assist and cooperate with the TAB contractor and CxA by:
   a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
   b. Including cost of sheaves and belts that may be required by TAB.
   c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. The Division 23 contractor shall provide an approved plug.
   d. Providing temperature and pressure taps according to the Construction Documents and at each water sensor which is an input point to the control system, for TAB and commissioning testing.
3. List and clearly identify on the as-built drawings the locations of all air-flow stations.
4. Prepare a preliminary schedule for Division 23 pipe and duct system testing, flushing and cleaning, equipment startup and TAB start and completion for use by the CxA. Update the schedule as appropriate.
5. Notify the Owner, CM/GC, or CxA depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the Owner, CM/GC, or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

Warranty Period

1. Participate in the near-warranty end (ten month) post occupancy visit.

B. Controls Contractor

Construction and Acceptance Phases

1. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components, and function.
b. All interactions and interlocks with other systems.
c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
e. Startup sequences.
f. Warm-up mode sequences.
g. Normal operating mode sequences.
h. Unoccupied mode sequences.
i. Shutdown sequences.
j. Capacity control sequences and equipment staging.
k. Temperature and pressure control: setbacks, setups, resets, etc.
l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
m. Effects of power or equipment failure with all standby component functions.
n. Sequences for all alarms and emergency shutdowns.
o. Seasonal operational differences and recommendations.
p. Initial and recommended values for all adjustable settings, set points and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
q. Schedules, if known.
r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

2. Control Drawings Submittal
   a. The control drawings shall have a key to all abbreviations.
   b. The control drawings shall contain graphic schematic depictions of the systems and each component.
   c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
   d. Provide a full points list with at least the following included for each point:
      1) Controlled system
      2) Point abbreviation
      3) Point description (e.g., DB temp, airflow, relative humidity, static pressure, etc.)
      4) Display unit
      5) Control point or set point (Point that controls equipment and can have its set point changed, e.g. OAT, SAT, etc.) (Yes / No)

6) Monitoring point (Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification) (Yes / No)
7) Intermediate point (Point whose value is used to make a calculation which then controls equipment, e.g. space temperatures that are averaged to a virtual point to control reset) (Yes / No)
8) Calculated point ("Virtual" point generated from calculations of other point values) (Yes / No)
9) Control dead bands and any applicable times for feedback control loops

e. The Controls Contractor shall keep the CxA informed of all changes to this list during programming and setup.

3. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
4. Assist and cooperate with the TAB contractor in the following manner:
   a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
   b. For a given area, have all required calibrations, startup, PFCs, and selected functional tests of the system completed and approved by the CxA prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB or provide sufficient training for TAB to operate the system without assistance.
5. Sensor and Actuator Calibration:
   a. All field-installed temperature, relative humidity, CO, CO_2 and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be field calibrated. Verify that all locations are appropriate and away from causes of erratic operation (i.e. unstable flow conditions, other heat sources, vibration, etc.).
   b. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances defined in the controls specification section of the instrument-measured value over the full range of expected control. If not, install offset in the BAS, calibrate or replace sensor.
6. Provide a signed and dated certification to the CxA and CM/GC upon completion of the checkout of each controlled device, equipment and system prior to FPT for each piece of equipment or system, that all system programming is complete.
7. Assist and cooperate with the CxA in the following manner:
   a. Using a skilled technician who is familiar with this building, execute the FPT of the controls system as specified for the controls contractor in the Cx Plan, Section 019113 and this Section. Provide two-way radios during the testing if necessary for communications.
   b. Execute all control system trend logs specified and as requested by the CxA.
8. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).
9. Assist the CxA with implementation and integration of the Monitoring-Based Commissioning (MBCx) hardware (agent) and software to perform MBCx services. This may require the

additional points in the BAS system to be made discoverable and implementing BACnet communications protocol, where necessary for interfacing.

Warranty Period

1. Participate in the near-warranty end (ten month) post occupancy visit

C. TAB Contractor

Construction and Acceptance Phases

1. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the Owner, CxA and CM/GC at least twice a week.
2. Communicate in writing to the controls contractor all set point and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
3. Provide a draft TAB report in accordance with specification [23####]. A copy will be provided to the Owner, design team and CxA.
4. Provide the CxA with any requested data, gathered, but not shown on the draft reports.
5. Provide a final TAB report for the Owner, design team and CxA with details, as in the draft. The final TAB Report shall be submitted with acceptance by the Engineer of Record before beginning TAB Verification.
6. Conduct FPT and checks on the original TAB as specified for TAB requirements in the Cx Plan and Section 019113.

1.4 RELATED WORK

A. Refer to Section 019113 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 019113 for systems to be commissioned.

1.5 SUBMITTALS

A. Division 23 contractor(s) shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 019113 for additional Division 23 requirements.

1.6 WEB-BASED COMMISSIONING PORTAL

A. All general and major contractors participating in the Cx process shall use the web-based Cx Portal, CxAlloy (“Portal” or “CxAlloy”) to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Startup Documentation, PFCs, FPTs and results, Issues Log tracking, project documents and deliverables. It also serves as a collaborative e-mail hub to facilitate, automate, and track communications between Parties relating to the Cx process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 23 contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 019113 for additional Division 23 test equipment requirements.

C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the contractor. The manufacturer shall provide the test equipment, demonstrate its use and assist the CxA in the Cx process.

2.2 INCIDENTAL EQUIPMENT

A. The Division 23 contractor shall provide all scaffolds, staging, ladders and accessories required to allow testing agencies, consultants and Owner's staff safe access to equipment, valves and other devices located above floor level.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Section 019113 for additional meeting requirements.

B. Participation at various commissioning meetings shall depend on the purpose of the meeting and may consist of, but not be limited to, the following members of the project commissioning team: the Owner's representative (i.e. project manager and/or facility staff), the CxA, the CM/GC, subcontractors and/or manufacturer's technical representative as required, the architect/engineer (A/E), and any specialists deemed appropriate by the Cx team.

C. All the listed Cx team members shall participate in the Cx kick-off meeting.

D. Participate, as applicable, in Cx coordination meetings in accordance with related Section 019113.

E. Participate, as needed, in deficiency resolution meetings.

3.2 STARTUP

A. The HVAC mechanical and controls contractors shall follow the startup, initial checkout procedures, and PFCs listed in the Responsibilities list in this section and Section 019113. The Division 23 contractor has startup responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility to the CxA or Owner.

B. FPT is intended to begin upon completion of a system. FPT will not proceed prior to the completion of systems, or sub-systems, which includes completion of the PFCs and approval of any necessary testing, adjusting and balancing (TAB) requirements.

3.3 PRE-FUNCTIONAL CHECKLISTS

A. Sampling Strategy: 100% of commissioned systems and equipment shall have PFCs completed and submitted for review and approval prior to functional performance testing. The CxA may observe the Division 23 contractor's completion of the PFCs.

B. Typical aspects of mechanical PFCs verify that the equipment matches the approved submittal, is installed properly, is started-up (and startup is documented) and integrated disciplines (i.e. electrical, equipment vendors, controls) have completed their work required for the equipment and system to function in its entirety. Examples would include spot checking of wiring/termination point-to-points and verification of alarm point parameters and messages.

3.4 CALIBRATION

A. Sensor and actuator calibration and calibration methods are covered in Section 019113 and Division 23 and are the responsibility of the Division 23 contractor.

3.5 TESTING PREPARATION

A. Inspect and verify the position of each device and interlock identified on checklists.

B. Certify that Mechanical systems, subsystems, and equipment have been installed, calibrated, started, quality control tested, and code tested (as applicable) and are operating according to the Contract Documents.

C. Certify that mechanical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest setpoints have been recorded.

D. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved by the Engineer of Record.

E. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.6 TAB VERIFICATION

A. Refer to Section 019113 for a description of the process.

B. Sampling Strategy: Follow the FPT sampling strategy for TAB verification.

C. Refer to the TAB contractor responsibilities in Part 1.3 above.

3.7 FUNCTIONAL PERFORMANCE TESTS

A. FPT is intended to begin upon completion of PFCs and startup of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and Owner. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all PFCs.

B. Refer to Section 019113 for a list of systems to be commissioned and a description of the process.

C. Sampling Strategy

1. Heating, ventilating and air conditioning (HVAC) systems and controls (1.5.1A.1A)
    a. VAV air handling unit (4 of 4)
    b. Dedicated outdoor air units (1 of 1)
    c. Energy recovery coils/systems (2 of 2)
    d. VAV terminal boxes (12 of 47)
    e. Laboratory supply/exhaust air valves (17 supply valves and 13 exhaust valves)
    f. Laboratory exhaust fans (4 of 4)
    g. General Exhaust fans (2 of 2)
    h. Ductless split system AC units (9 of 9)
    i. Hot water unit heater (1 of 1)
    j. Building automation system (control and interface associated with commissioned systems)

D. Refer to Section 019113, Sampling for the Sampling/Failure Rule.

E. Typical aspects of mechanical FPTs verify that systems, subsystems and equipment function interactively and throughout the full range of operating conditions (e.g. low load, design load, component failures, alarm conditions, safety interlocks including with life safety systems, etc.) and modes (e.g. normal shutdown, normal auto position, normal manual position, power failure including control power, emergency power, unoccupied, fire alarm, etc.). The systems are run through all the control system’s sequences of operation and components are verified to be responding as the sequences state**.** Positive confirmation of state/status shall be shown both locally and via the BAS, as specified in the Contract Documents.

F. Development of Test Procedures: Before test procedures are written, the CxA shall obtain project contract documentation and a current list of change orders and RFI's affecting equipment or systems, including an updated points list, program code, control sequences and parameters and electrical coordination study. The CxA shall develop specific test procedures and forms for evaluating performance of all integral components and their functioning as a complete unit within design requirements and manufacturer's published data. Prior to execution, the CxA shall provide a copy of the test procedures to the Contractors who shall review the tests for feasibility, safety, equipment and warranty protection.

3.8 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 019113 for specific details on non-conformance issues relating to PFCs and tests.

B. Refer to Section 019113 for issues relating to functional performance tests.

3.9 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. Division 23 contractor shall compile and prepare documentation for all equipment and systems covered in Division 23 and deliver to the CM/GC for inclusion in the O&M manuals.

C. The CxA shall receive a copy of the O&M manuals for concurrent review and comment with the A/E.

3.10 SYSTEMS MANUAL REQUIREMENTS

A. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references. The CM/GC shall include final approved versions of the following information for the Systems Manual:

1. As-Built System Schematics
2. Verified Record Drawings
3. As-built control drawings and sequences of operation, along with final system setpoints
4. Test Results (not otherwise included in Cx Record)
5. Periodic Maintenance Information for for all commissioned equipmnet
6. Recommendations for recalibration frequency of sensors and actuators
7. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
8. Training Records, Information on training provided, attendees list, and any on-going training

B. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.

C. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.11 TRAINING OF OWNER PERSONNEL

A. Training shall be in accordance with ASHRAE Standard 202-2018, *Commissioning Process for Buildings and Systems*, and ASHRAE Guideline 0-2019, *The Commissioning Process*.

B. The CM/GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed in accordance with Division 1 requirements. Refer to Section 019113 for additional details.

C. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 019113 for additional details.

D. Mechanical Contractor: The mechanical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan eight (8) weeks before the planned training according to the outline described in Section 019113.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, all HVAC equipment (ex. pumps, heat exchangers, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.)
3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the startup technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
8. Training shall include:
    a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include startup, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

c. Discussion of relevant health and safety issues and concerns.
d. Discussion of warranties and guarantees.
e. Common troubleshooting problems and solutions.
f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discussion of any peculiarities of equipment installation or operation.
h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1, is recommended.
i. Classroom sessions shall include the use of overhead projections, slides, and video/audio-taped material as might be appropriate.

9. Hands-on training shall include startup, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance for all pieces of equipment.
10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
11. Training shall occur after FPT is completed, unless approved otherwise by the Owner.

E. Controls Contractor: The controls contractor shall have the following training responsibilities:
1. Provide the CxA and AE with a training plan eight (8) weeks before the planned training.
2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA and A/E.
4. The training will be tailored to the needs and skill-level of the trainees.
5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.
6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary, and the demonstration repeated.
7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
8. There shall be three (3) training sessions:
a. Training I. Control System. The first training shall consist of 8 hours of actual training. This training may be held on-site or in the supplier’s facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.

b. Training II. Building Systems. The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
   1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
   2) Security levels, alarms, system startup, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
   3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
   4) Every screen shall be completely discussed, allowing time for questions.
   5) Use of keypad or plug-in laptop computer at the zone level.
   6) Use of remote access to the system via phone lines or networks.
   7) Setting up and changing an air terminal unit controller.
   8) Graphics generation.
   9) Point database entry and modifications.
   10) Understanding DDC field panel operating programming (when applicable).

c. Training III. The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

F. TAB Contractor: The TAB contractor shall have the following training responsibilities:
   1. TAB shall meet for 4 hours with facility staff after completion of TAB and instruct them on the following:
      a. Review and discuss the final TAB report, explaining the layout and meanings of each data type.
      b. Identify and discuss any units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
      c. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
      d. Other salient information that may be useful for facility operations, relative to TAB.

3.12 DEFERRED TESTING

A. Refer to Section 019113 for requirements of deferred testing.

3.13 WRITTEN WORK PRODUCTS

A. Written work products of the Division 23 contractors will consist of the completed PFCs and the completion of startup and initial checkout plan described in Section 019113.

END OF SECTION 230813

SECTION 23 09 00 – BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes fully integrated building automation system, incorporating Direct Digital Control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as shown on the drawings and as described herein. Drawings are diagrammatic only.

B. Alternates: Work of this Section is affected by an Alternate. Refer to Section 01 23 00 - Alternates

1.02 RELATED DOCUMENTS

A. WTCC Building Automation System Guidelines BASGv3.05.

B. WTCC BAS Guidelines Point Library Table

C. WTCC BAS Guidelines Point Library Schematic

1.03 SYSTEM DESCRIPTION

A. Automatic temperature controls field monitoring and control system using field programmable microprocessor-based units.

B. The BAS shall be based on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit communicating via BACnet communication protocols or Ethernet / IP (preferred).

C. Include computer software and hardware, operator input/output devices, control units, sensors, control devices, electronic actuators as necessary for a fully functional controls system.

D. Provide control systems consisting of thermostats, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.

E. Include installation and calibration, supervision, and fine-tuning necessary for complete and fully operational system.

F. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

G. WTCC hosts 3 software licenses on the Energy Management and Information System (EMIS) server:
   1. FIN: BAS front end supervisor
   2. Skyspark: BAS analytics
   3. Periscope: BAS dashboard.

H. Master System Integrator (MSI) shall integrate directly into WTCC's EMIS Front End Software-FIN. Refer to Section 25 15 10 "Master Systems Integration" for more information.

1.04 SCOPE

A. The BAS is an open protocol BACnet communication DDC system. The BAS will be a stand-alone system capable of operating the building by itself. The college requires every building BAS to be connected to a common server known as the Energy Management and Information System (EMIS) . The EMIS is responsible for BAS front end functions such as building equipment and floor graphics, data fault detection and analytics, alarming, trending, scheduling, etc. The EMIS 'integration' shall be performed by a Master System Integrator (MSI) during the project. The BAS contractor will coordinate with WTCC on the MSI scope of work. MSI contract shall be directly with WTCC and does not need to be included in the construction bids.

B. Furnish and install a Building Automation System (BAS) as detailed within these specifications. This system shall be provided, erected, assembled and installed by the control system manufacturer or the manufacturer's authorized representative and utilizing technicians and

mechanics regularly employed by the control manufacturer or the manufacturer's authorized representative. The Building Automation System of this defined project, as specified, will be capable of complete stand-alone operation and must include, but are not limited to the required features, options and functions. The system shall be connected to the Building BAS VLAN network. One network switch and network data connection to the campus network will be provided by others, however all other necessary equipment, connections, programming, etc. required to make the system fully functional per this specification shall be provided by the controls contractor as part of this contract.

C. The BAS Contractor shall be responsible for all new controllers, control devices, control panels and enclosures, controller programming, controller programming software, controller input/output and power wiring and controller network wiring. The MSI contractor shall be responsible for setup of alarms, schedules and trends (AST) on field controllers.

D. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the functional intent of this specification and equipment/system sequence of operations shall be provided without additional cost to the Owner.

E. Air handling unit control/end devices shall be furnished by the BAS manufacturer and factory installed by the air handling unit manufacturer. Controls contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings.

F. All variable frequency drives shall interface to the Building Automation System (BAS) via BACnet IP.

1.05 MASTER SYSTEMS INTEGRATOR OVERVIEW

A. FIN Stack (FIN), developed by J2Innovations – a wholly owned subsidiary of Siemens AG, is the BAS EMIS software hosted on the WTCC server. FIN is designed to be open; supporting all the major protocol standards to enable integration with multiple building level systems and IoT deployments.

B. The Master System Integrator (MSI) shall only integrate from the Building Level equipment controllers to the existing EMIS Server. WTCC requires the Master System Integrator (MSI) to be a FIN Certified Integrator with experience integrating through BACnet and nHaystack connections.

C. It is WTCC's goal to integrate from high level field controllers (e.g., a B-BC or B-AAC) to a FIN front end server to be a single location to view graphics, and interact through point overrides, and to manage alarming, scheduling and trending (AST). FIN leverages the project Haystack opensource metadata protocols by using tagging to automate configuration processes and deliver context-sensitive information to give a highly intuitive user experience. This allows building systems from various distributors to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the BAS system. The Owner, Wake Technical Community College, shall be the named license holder of all software associated with any and all incremental work on the projects.

1.06 OTHER EMIS APPLICATIONS

A. Overview
   1. WTCC has licensed and maintains an enterprise analytics application to run Fault Detection and Diagnostics (FDD). This analytics platform is SkySpark, developed by SkyFoundry. SkySpark can be configured to:
      a. Identify HVAC system-level and equipment-level faults that if mitigated, can save energy, reduce demand, and/or improve occupant comfort and health, including (but not limited to)
         1) Economizer operation,
         2) Simultaneous heating and cooling,
         3) Photocell malfunction,
         4) Additional HVAC and lighting setpoints.

b. Provide early identification of faults to extend equipment life, and
c. Visualize and provide regular reports to managers, technicians and other personnel on building performance.

2. The College has also licensed Periscope, developed by Building Controls and Solutions (previously Activelogix), as its energy, water and transportation dashboard.
3. Dashboard software is an advanced Energy Information System that allows non-facilities stakeholder to monitor and raise awareness of sustainability metrics at WTCC. Campus, building or transportation specific dashboards can be comprised of one or more viewlets that track consumption, demand or other metrics related to energy, water and transportation. An important feature of dashboards is to represent consumption or demand metrics in the form of equivalencies. For example, energy reductions can be represented in the form of reduced carbon emissions or number of trees planted.

B. Building Data
1. These enterprise applications can poll building level BAS systems for information. However, at the time this standard was written, both applications use data trended in FIN for analytics and dashboarding. This is possible because FIN, SkySpark and Periscope run on the SkySpark platform.
2. The Contractor's building-level BAS shall provide trends to these enterprise applications via BACnet or other approved protocol over the WTCC IT network.

1.07 WORK BY OTHER TRADES

A. Control Devices Furnished by BAS Contractor for Installation by other trades.
1. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
2. Deliver the following to duct fabricator and installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
a. Automatic control dampers, where not supplied with equipment.
b. Airflow sensors, switches and stations
c. Pressure sensors.
d. Terminal unit controllers and actuators, when installed by terminal unit manufacturer.
3. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
a. DDC control valves
b. Pipe-mounted flow meters and BTU meters
c. Pipe-mounted sensors, switches and transmitters.
d. Tank-mounted sensors, switches and transmitters.
e. Pipe- and tank-mounted thermowells and other inline hardware for sensors.
4. Deliver the following to electrical installers for installation. Include installation instructions to Installer and supervise installation for compliance with requirements.
a. Meters/Sub-Metering Devices

B. Products Requiring Communication Interface
1. Integration Meeting: The BAS contractor shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the BAS system.
a. The Owner or his designated representative shall be invited to this meeting.
b. Each Installer shall provide the Owner and all other Installers with details of the proposed interface including PICS for BACnet equipment, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories.
c. The purpose of this meeting shall be to ensure there are no unresolved issues regarding the integration of these products into the BAS system.

d. Submittals for these products shall not be approved prior to the completion of this meeting.

2. BAS shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
   a. AHU modular needlepoint bipolar ionization system
   b. Air-compressor
   c. Automatic transfer switch (ATS)
   d. Domestic hot water recirculation pumps
   e. Domestic hot water heat exchanger system
   f. Emergency engine generators
   g. Fan Filter Unit
   h. Gas-fired steam humidifier
   i. Gas manifolds
   j. Smoke detectors (through alarm relay contacts)
   k. Sump pump unit controllers
   l. Variable-frequency controllers
3. BAS shall have a communication interface with systems having a communication interface.
   a. Fire-alarm panel
   b. Lighting controls. BAS shall connect to Lighting Control system for lighting control. Refer to the electrical drawings for location.

C. The BAS contractor shall cooperate with the air and water balancing agency in the performance of their work as required or directed.

1.08 ACTION SUBMITTALS:

A. Product Data: For each type of product include the following:
1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
   a. Gateways.
   b. Routers.
   c. DDC controllers.
   d. Enclosures.
   e. Electrical power devices.
   f. UPS units.
   g. Accessories.
   h. Instruments.
   i. Control dampers and actuators.
   j. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Shop Drawings:
1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
c. Drawings Size: 11x17.

2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:
   a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
   b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
   c. Each gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
   d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
   e. Network communication cable and raceway routing.
   f. Information, drawn to scale, of ¼”=1’-0”.
   g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
6. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
   c. Front, rear, and side elevations and nameplate legend.
   d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each. Indicate BACnet Device ID.
   d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
9. DDC system electrical power riser diagram indicating the following:

a. Each product requiring power with associated requirements (volts/phase//hertz/amperes/connection type) listed for each.

10. Monitoring and control signal diagrams indicating the following:
    a. Control signal cable and wiring between controllers and I/O.
    b. Point-to-point schematic wiring diagrams for each product.
    c. Control signal tubing to sensors, switches and transmitters.
    d. Process signal tubing to sensors, switches and transmitters.

C. System Description:
1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
    a. Loss of power.
    b. Loss of network communication signal.
    c. Loss of controller signals to inputs and outpoints.
    d. Operator workstation failure.
    e. Server failure.
    f. Gateway failure.
    g. Network failure
    h. Controller failure.
    i. Instrument failure.
    j. Control damper and valve actuator failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.09 CLOSE OUT DOCUMENTATION:

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

B. BAS Controls Contractor:
1. One cleaned up version of ‘as-built’ control drawings in .pdf.
    a. Include Network Architecture spreadsheet with Device Name, Location, Firmware, IP address, MAC address, BACnet Network #, & BACnet device instance #.
2. Five (5) paper copies of ‘as-built’ control drawings to be handed out during Owners Training.
3. If Distech product is used: Network Utility Export File-listing every ECY/ECB on BACnet IP network.
4. Backup copy of graphic files, programs, and database on electronic media such as digital media.
    a. Include backup configuration files for every BAS Controller.
    b. Prior to project acceptance by the WTCC project manager, a backup file of all DDC field controllers shall be created and turned over to WTCC. This file shall be generated by upload and contain programming for each field controller as it exists on the date of project acceptance.
5. Each control cabinet shall include one laminated schematic, wiring diagrams, sequence of operation for equipment being controlled.
6. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
7. As-built versions of submittal Product Data.
8. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

9. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
10. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
11. Engineering, installation, and maintenance manuals that explain how to:
    a. Design and install new points, panels, and other hardware.
    b. Perform preventive maintenance and calibration.
    c. Debug hardware problems.
    d. Repair or replace hardware.
12. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
13. List of recommended spare parts with part numbers and suppliers.
14. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
15. Visio files used to create Controls Submittal; network architecture.
16. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
17. Licenses, guarantees, and warranty documents.
18. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
19. Owner training materials.
20. Final contractor checkout sheets, including calibration checks, offsets used, and final values compared to measured values.

C. Mechanical Contractor/Designer
    1. Mechanical and Electrical AutoCAD floorplan drawings. Drawings shall be used by MSI in creating floorplan graphics.
    2. One cleaned up version of ‘as-built’ ME drawings in PDF and AutoCAD format.

1.10 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing, installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project.
    1. Design system software under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State of North Carolina.

B. The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 100 miles of Raleigh, NC with technical staff, spare parts inventory and necessary test and diagnostic equipment.

C. The manufacturer shall provide onsite, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS.

D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

E. The manufacturer of the BAS digital controllers shall, if requested, provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing).

1.11 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in

writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

1.12 PERFORMANCE REQUIREMENTS

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).
   1. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
   2. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec from the Web User Interface.
   3. Alarm Response Time. An object that goes into alarm shall be annunciated at the on the Web User Interface within 45 sec.
   4. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
   5. Performance. Programmable controllers shall be able to completely execute PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
   6. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
      a. Water Temperature: Plus or minus 1 deg F.
      b. Water Flow: Plus or minus 2 percent of full scale.
      c. Water Pressure: Plus or minus 1.0-inch wg..
      d. Space Temperature: Plus or minus 1 deg F.
      e. Ducted Air Temperature: Plus or minus 1 deg F.
      f. Outside Air Temperature: Plus or minus 2 deg F.
      g. Dew Point Temperature: Plus or minus 3 deg F.
      h. Temperature Differential: Plus or minus 0.25 deg F.
      i. Relative Humidity: Plus or minus 5 percent.
      j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
      k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
      l. Airflow (Terminal): Plus or minus 10 percent of full scale.
      m. Air Pressure (Space): Plus or minus 0.01-inch wg.
      n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
      o. Carbon Dioxide: Plus or minus 50 ppm.
      p. Electrical: Plus or minus 5 percent of reading.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

1.13 IDENTIFICATION

A. Identify control wires with point name on a nonconducting tag attached to each end or at junction points. Designate on control diagram the identifying point name used.

B. Identify all control equipment and devices, including panels, controllers, valves, and automatic dampers, firestats, etc., by a method approved by the Architect. Designations shall match those used on control diagrams and shop drawings.

1.14 NATIONAL CODES, STANDARDS AND REGULATORY REQUIREMENTS

A. The BAS shall comply with all governing codes, ordinances, and regulations, including UL, NFPA, State and local Building Code, and NEC.

B. NFPA 70 – National Electric Code (NEC)

C. ASHRAE - American Society of Heating, Refrigeration, and Air-Conditioning Engineers
   1. ASHRAE Guideline 36, High-Performance Sequences of Operation for HVAC Systems.
   2. ANSI/ASHRAE Standard 62.1, Ventilation and Acceptable Indoor Air Quality
   3. ANSI/ASHRAE Standard 90.1, Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings
   4. ANSI/ASHRAE Standard 135, BACnet: A Data Communication Protocol for Building Automation and Controls Networks.

D. UL 916 – Standard for Energy Management Equipment

E. Project Haystack. Project-haystack.org

F. FCC – Part 15, Subpart J

G. City, County, State, and Federal regulations and codes in effect as of the date of Contract.

H. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc.

I. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

J. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.

1.15 LICENSING

A. All hardware, software and licensing of BAS and related components including analytics and dashboarding systems, shall be provided by Installer for a period of three years (36 months) from date of project acceptance by the WTCC Project Manager.

1.16 DELIVERY, STORAGE AND HANDLING

A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.17 PRE-INSTALLATION MEETING

A. BAS contractor shall initiate a meeting two weeks following submittal date with the Owner, Engineer, Commissioning Agent, Mechanical Contractor, BAS Contractor and all parties directly affecting the work of this section to review engineer and owner comments and to finalize the submittal. If the engineer does not feel the submittal can be approved, then this meeting shall occur after resubmittal.

B. Reference integration meeting requirements defined above.

1.18 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion.

B. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

1.19 WARRANTY

A. The BAS shall be free from defects of material, and workmanship under normal use and service for a period of 12 months after final acceptance by the Owner.

B. If within the 12-month warranty period, any equipment, software, or labor is found to be defective in workmanship or materials, it shall be replaced by the Contractor at no cost to the owner.

C. Warranty service calls shall be available to the job site during normal working hours.

D. Just before or at the end of the warranty period, update equipment firmware and software applications provided under these specifications to the latest manufacturer versions available for sale at the time.

1.20 SPECIFICATION NOMENCLATURE AND DEFINITIONS

A. Acronyms used in this specification are as follows:
1. Actuator: Control device that opens or closes valve or damper in response to control signal
2. AI: Analog Input. Proportional input signal (zero- to 10-V dc, 4 to 20 mA)
3. AO: Analog Output. Proportional output signal (zero- to 10-V dc, 4 to 20 mA).
4. Analog: Continuously variable state over stated range of valves
5. ASO: Automated System Optimization
6. BACnet: Building Automation and Control Network
7. BAS: Building Automation System
8. BI: Binary Input. On/off input signal or contact closure.
9. BO: Binary Output. On/off output signal or contact closure.
10. DDC: Direct Digital Control
11. Discrete: Binary or Digital State
12. EIS: Energy Information System
13. EMIS: Energy Management Information System
14. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
15. FDD: Fault Detection and Diagnostics
16. FO: Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
17. GUI: Graphical User Interface
18. HMI: Human Machine Interface
19. HVAC: Heating, Ventilating and Air Conditioning
20. IDC: Interoperable Digital Controller
21. ILC: Interoperable Lon Controller
22. LAN: Local Area Network
23. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input valve.
24. Motorized: Control device with actuator.
25. MSI: Master System Integrator
26. NAC: Network Area Controller
27. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
28. NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
29. OSS: Operating System Server, host for system graphics, alarms, trends, etc.
30. Operator: Same as actuator
31. PC: Personal Computer
32. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
33. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
34. PI: Proportional-Integral control; control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controller variable (reset control).
35. PICS: BACnet Product Interoperability Compliance Statement
36. PID: Proportional-Integral-Derivative control; control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it’s changing (derivative).
37. Point: Analog or discrete instrument with addressable database value.
38. VBC: VAV Box Controller
39. VFD: Variable Frequency Drive

40. WAN: Wide Area Network

1.21 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 MATERIALS

2.01 APPROVED MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products and services by one of the following:
   1. JCI Facility Explorer (FX) – CCT
   2. Distech Controls – EC-GFX

B. BAS equipment shall only be installed by companies who are current, actively licensed VARs (value added resellers) or VADs (value added distributors). WTCC maintains a list of approved contractors.

2.02 GENERAL

A. Field equipment controllers (FEC) shall be BACnet IP or BACnet MSTP compliant. Field controllers should have BACnet Testing Labs (BTL) certifications as B-AAC (BACnet Advanced Application Controller), B-ASC (BACnet Application Specific Controller), or B-BC (BACnet Building Controller) devices.

B. Supervisory control devices that require software licensing and ongoing service maintenance agreements are expressly prohibited (e.g. N4 JACEs). This prohibition also extends to BAS servers functioning as a building level supervisory controller that require ongoing software licensing or service maintenance agreements (SMAs).

C. In order to improve communication with EMIS software (BAS, analytics, dashboarding or other functions), the Contractor shall consider using middle-ware devices in buildings to communicate downstream to FECs via BACnet and upstream to EMIS software using other, presumably more efficient, communication protocols.

D. BAS equipment shall only be installed by companies who are current, actively licensed VARs (value added resellers) or VADs (value added distributors). WTCC maintains a list of approved contractors.

2.03 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate OBIX (XML), OPC, SNMP, BACnet IP, BACnet MSTP, Modbus TCP/IP, Modbus RTU, or proprietary legacy communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-2001, and BACnet to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP,) and/or RS-485 (BACnet MSTP) as specified. For each Modbus device supplier must provide a Registry of data points available on the system.

C. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

D. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. Systems requiring proprietary database and user interface programs shall not be acceptable.

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
   1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
   2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.04 NETWORKS

A. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Area Controllers (NACs).

B. Local area network minimum physical and media access requirements:
   1. Ethernet; IEEE standard 802.3
   2. Cable; 100 Base-T, UTP-8 wire, category 6
   3. Minimum throughput; 100 Mbps.

2.05 COMMUNICATION SPEED

A. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements.

B. 5 seconds between a Priority 1 (critical) alarm occurrence and enunciation at operator workstation.

C. 10 seconds between a Priority 2 alarm occurrence and enunciation at operator workstation.

D. 10 seconds between an operator command via an operator interface to change a setpoint and the subsequent change in the controller.

E. 5 seconds between an operator command via an operator interface to start/stop a device and the subsequent command to be received at the controller.

F. 10 seconds between a change of value or state of an input and it being updated on an operator interface.

G. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points.

2.06 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
   1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 23 09 93. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.

F. System shall be expandable with additional controllers, associated devices, and wiring. WTCC requires the ability to add up to 5 future devices, with a minimum of 50 points per device, to account for expansion.

G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
3. For read or write requests, the system shall require username and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.
4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third-party Web services device to read data from or write data to any object in the system which supports this service.

H. Local Ethernet Port
1. The local Ethernet port of the BAS field panel or controller shall be capable of supporting network speeds no lower than the 10/100Base-T standard. If faster communications are required to interface with the EMIS through the WTCC IT network, Contractor is responsible for installing such devices.
2. The BAS system must be capable of updating a COV from any point on the system across the network to the WTCC EMIS server with less than 10 seconds of latency at all times.
3. BACnet IP
a. The building level BAS must include the ability to perform all AST functions via BACnet IP or BACnet MSTP.
b. Once the BAS is integrated to the EMIS Server, the BAS Contractor shall participate in performance testing and tuning BAS components. Potential issues include, but are not limited to, response time (or time-outs) on AST functions, polling intervals, or field controller processor and memory performance.
c. All upstream communication to the EMIS server shall be via BACnet IP, or, if required to prevent overloading the IT network infrastructure, a more efficient communication protocol (e.g., TCP/IP).

2.07 CONTROLLER SOFTWARE

A. BAS Contractor shall load all attendant software required to remotely support, troubleshoot and backup the building level BAS on the ET-BAS server at WTCC (e.g. Distech package files, JCI FX package files) to maintain and remotely support all BAS components.
1. Software is currently in use by the college and is open to multiple vendors to install and service.
2. Approved field controller software is listed below:
a. Facility Explorer (FX) - CCT
b. Distech – EC-GFX

B. Programming
   1. Graphical Programming shall be provided with printed narratives and/or flow diagrams to document algorithms and how to modify and use them. The engineering tool shall be capable of accessing the controller directly from a portable (laptop) PC and accessing a controller through the IT network from a server maintained by WTCC.

C. BACnet Instance Numbers (BACnet ID)
   1. There must be no duplication of BACnet Device ID's. Contractor shall obtain a range of BACnet device IDs for use on each project from the WTCC Project Manager and the BAS Controls Engineer.

D. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule, communicated to the BAS from the EMIS.

E. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

F. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

G. Analog Alarms. Each analog object shall have both high and low alarm limits.

H. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms.

I. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in 23 09 93 (Sequences of Operation).

J. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

K. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

L. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

M. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse- acting.

N. Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Section 23 09 93 (Sequence of Operations).

2.08 CONTROLLERS

A. Overview. At the equipment level, the Direct Digital Controlled system shall be comprised of BACnet IP/MSTP type compliant equipment controllers. In the event of a communications failure from the Building Supervisor, the BACnet controller shall be capable of operating in a standalone mode. All devices shall be UL listed, FCC approved, and BACnet Compliant.
   1. WTCC intends to maintain licenses for the EMIS BAS (FIN) and other EMIS software applications including analytics and dashboarding.
   2. At the building level, BACnet building controllers (B-BC) that do not require software licensing shall be used with high level field controllers such as BACnet advanced application controllers (B- AAC) and lower level BACnet application specific controllers (B-ASC) to perform BAS functions.

3. Prior to programming controllers, the BAS Controls contractor shall request a meeting with WTCC. At this meeting, WTCC will provide some or all of the following information:
   a. BAS Point Library Schematic and BAS Point Library Table,
   b. Schedule requirements,
   c. WTCC TC/IT Network Requirements,
   d. A defined range of BACnet device ID numbers to use on the project, and
   e. A Metering Standard.

B. General. Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Section 23 09 23 Article 1.9 (System Performance). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

C. Override at Field Controller. B-BC and B-AAC field controllers must allow override of writeable points directly at a local controller display. No external hardware or software is required.

D. BACnet.
   1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B- BC in the BACnet Testing Laboratories (BTL) Product Listing.
   2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
   3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
   4. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
   5. BACnet Communication.
      a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
      b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
      c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
      d. Each ASC shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
      e. Each SA shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.
      f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using MS/TP Data Link/Physical layer protocol.

E. Communication
   1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator’s Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
   2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment specified in Section 23 09 93 shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

F. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

G. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

H. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

I. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

J. Memory.
1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

K. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

L. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

M. Input and Output Interface
1. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.
2. Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.
3. Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.
4. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

5. Analog Inputs. Analog inputs shall allow the monitoring of low-voltage (0–10 Vdc), current (4– 20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
6. Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.
7. Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.
8. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri- state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.
9. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.
10. System Object Capacity. The system size shall be expandable to add up to 5 future devices, with a minimum of 50 points per device. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.09 NATIVE TRENDING (DIVISION 25 MSI SCOPE – INCLUDED FOR REFERENCE ONLY)

A. At a minimum, provide programming and trending for Points as follows:
   1. Create extensions for every physical input and output in the system. The TL objects should reside in a B-BC, B-AAC or B-ASC field controller.
   2. With the exception of points identified below, analog data shall be trended on a 15-minute interval. This includes but is not limited to analog inputs, outputs, and automatically resetting set-points. Examples include space temperatures, PID loop inputs and outputs,
   3. Boolean data points shall be trended on change of value (CoV): inputs and outputs.
   4. Each B-AAC and B-BC field controller shall be capable of storing all trend data locally for a minimum of 3 days and preferably for 5 days. Trend data for B-ASC devices must be stored in these high-level controllers if the B-ASC device cannot store and pass along trends to the EMIS server.
   5. Trend data shall be synced to the EMIS server for input to the College's data historian. Currently the data historian resides on the SkySpark platform. Trend data may be pulled from field controllers by FIN or SkySpark or other applications.

2.10 METER TRENDING (DIVISION 25 MSI SCOPE – INCLUDED FOR REFERENCE ONLY)

A. Each measured value shall be available at the EMIS BAS as both a live and historical value.

B. Meters shall capture data 24 hours a day and 7 days a week. Data shall be stored locally in accordance with OEM specifications.

C. Live measured values shall be displayed in the EMIS BAS as well as future Dashboards. Historical data shall be displayed in charts and reports via the Analytics platform; it shall also be accessible in the EMIS BAS. Historical data can be added to graphics in the EMIS BAS as well as future Dashboards as deemed appropriate.

D. Data trending requirements at the BAS/Dashboard Server:
   1. Meter consumption data shall not be set up to rollover or reset to zero at any point. This only applies to consumption values that are totalizing in nature such as electrical consumption (kWh), CHW & HHW BTU consumption, water consumption (gal), and gas consumption (cf). Instead, the monthly/daily/hourly data can be viewed in a "delta" format, whereby the difference or change in a consumption value from one timestamp to the next

is calculated. Delta histories are preferred if the meter has an inherent register rollover value because they are more fault tolerant for long term data collection.
   a. These calculations shall be performed and viewed in SkySpark.
   b. If future Dashboards require delta histories to be represented as a point, the calculations shall be performed in the EMIS BAS software.
2. Unless otherwise noted, all specified measured values shall be captured in 15-minute increments at the EMIS BAS.
3. Meter interval data shall be captured with a timestamp ending with :00, :15, :30, and :45 for every hour of data recorded for consistency with utility billing. For example, a trend shall be captured at 1:00, 1:15, 1:30, 1:45, and 2:00 pm, etc.

E. Monthly Utility Bill Data (Responsibility of WTCC – Included for Reference Only):
1. WTCC utilizes Capturis to track their monthly utility use and cost for electric, gas and water accounts. Monthly utility billing determinants and values are imported to the EMIS via SkySpark.
2. All available monthly utility bill data (dates, consumption, account number, and cost) shall be imported to SkySpark on the first of each month.

2.11 MODBUS SYSTEM DEVICES

A. The EMIS/FIN shall support the integration of device data from Modbus TCP and TCP control system devices as a last resort. BACnet IP preferred.
1. Modbus TCP control system devices shall integrate directly to EMIS/FIN.
2. Modbus RTU control system devices shall have IP router to integrate directly to EMIS/FIN.

B. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the EMIS/FIN. Objects provided shall include at a minimum:
1. Read/Write Modbus AI Registers
2. Read/Write Modbus AO Registers
3. Read/Write Modbus BI Registers
4. Read/Write Modbus BO Registers

2.12 BAS ALARMING AND REPORTING (DIVISION 25 MSI SCOPE – INCLUDED FOR REFERENCE ONLY)

A. Alarming Overview: (Contractor shall obtain Alarm priorities from the WTCC Project Manager) These alarms will be synched to the EMIS using standard BACnet protocol when the field controller is connected to the network. Notifications of these alarms will be sent out via FIN front end.

B. Alarm extensions shall be created and prioritized according to (WTCC) BAS Alarm Standards. Operators with sufficient privilege shall be able to read and write alarm parameters for all standard BACnet alarm types. Operators with sufficient privilege shall be allowed to change routing (BACnet notification classes) for each alarm including the destination, time delay, priority class, day of week, time of day, and the type of transition involved.

C. Alarms shall be programmed with time delays and other logic to prevent nuisance tripping. Elimination of nuisance alarm notifications is a priority at (WTCC).

D. In order for alarm notifications to be sent to the correct email recipients, the Contractor shall use BACnet alarm levels shown in the BACnet Alarm Level – Notification Table below.

BACnet Alarm Level	WTCC Alarm Priority	Notification
10	A1	Email sent to WTCC & MCSP. Call center notified.
15	A1 & IT	Email sent WTCC, MCSP. Call Center & IT notified.
20	A2	Email sent to WTCC & MCSP.
30	Default	No notification. Alarm is logged and sent via daily digest.

E. Use BACnet notification class divisions to assign priorities to alarms and use the Alarm Level Mapping shown in Table 4.2a of the WTCC Building Automation System Guidelines BASGv3.05 for alarm notifications.

F. Alarm Programming
   1. Each B-AAC or B-BC controller shall provide alarm recognition, storage, routing, management. These devices should maintain alarming functionality within their network in the event of communication failure to the front-end EMIS system. Therefore, critical and default alarms will be programmed and classified in the B-BC and/or B-AAC controllers and pushed to the front-end. These alarms will be synced using the standard BACnet protocol when the device is connected to the EMIS. Notifications will be provided by the front-end system during typical operation. Alarms classified as critical will send out an immediate notification (BACnet Alarm Levels 10, 15 and 20), while those classified as default (BACnet Alarm Level 30) will be sent out in a daily digest/summary. Note that Level 20 alarms shall not be sent to the Call center. Table 4.2a below displays a list of Critical Alarms that shall be programmed into each B-BC or B-AAC.

G. Critical Alarms
   1. WTCC maintains a Critical Alarm List. Contractors shall obtain the current list from the WTCC Project Manager. Table 4.2a of the WTCC Building Automation System Guidelines BASGv3.05 displays a list of Critical Alarms that shall be programmed into each B-AAC or B-BC.

H. Alarms generated by equipment, where the BAS system is not responsible for the alarm logic, shall be passed by the BAS system to the EMIS as a digital input. All other alarms, where indicated in the drawings or specifications, or as indicated by the owner, and requiring logic, shall be generated at the EMIS.

I. Reporting shall be completed by the MSI.

2.13 FIELD DEVICES

A. Expansion Input/Output Module (EIOM)
   1. The EIOM provides additional input and output interfaces for use in digital controllers.
   2. The EIOM shall communicate with controllers over the FC Bus or the SA Bus.
   3. The EIOM shall support BACnet Standard ANSI/ASHRAE 135.
      a. The EIOM shall be BTL listed/certified and carry the BTL Label.
      b. The EIOM shall be tested and certified as a BACnet Smart Actuator (B-SA).
      c. A BACnet Protocol Implementation Conformance Statement shall be provided for the IOM.
   4. The EIOM shall include removable screw terminal blocks for all I/O, SA/FC bus communication, and power wiring connections.
   5. The EIOM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.
   6. The IOM shall accommodate the direct wiring of analog and binary I/O field points with the following resolution:
      a. Inputs – 24-bit analog-to-digital converter
      b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
   7. The EIOM shall support the following types of inputs and outputs:
      a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
      b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
      c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
      d. Binary Outputs – 24 VAC Triac
      e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output
   8. The EIOM shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.

B. Networked Thermostat (TEC)
   1. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.
      a. Two-line, 8 character backlit display
      b. LED indicators for Fan, Heat, and Cool status
      c. Five (5) User Interface Keys
         1) Mode
         2) Fan
         3) Override
         4) Degrees C/F
         5) Up/Down
   2. The Networked Thermostats shall provide the flexibility to support the following inputs:
      a. Integral Indoor Air Temperature Sensor
      b. Duct Mount Air Temperature Sensor
      c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator.
      d. Two configurable binary inputs
   3. The Networked Thermostats shall provide the flexibility to support the following outputs:
      a. Three Speed Fan Control
      b. On/Off Control
      c. Floating Control
      d. Proportional (0 to 10V) Control

C. Network Sensors (NS)
   1. The Network Sensors (NS) shall have the ability to monitor the following variables all within a single wall-mounted enclosure (no exceptions) as required by the systems sequence of operations:
      a. Zone temperature
      b. Zone humidity
      c. Zone carbon dioxide
      d. Zone set point
   2. The NS shall transmit the zone information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135.
   3. The NS shall be BTL listed/certified and carry the BTL Label.
      a. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
   4. The Network Zone Temperature Sensors shall include the following items:
      a. A backlit LCD to indicate the temperature, humidity and setpoint
      b. An LED to indicate the status of the Override feature
      c. A button to toggle the temperature display between Fahrenheit and Celsius
      d. A button to program the display for temperature or humidity
      e. A button to initiate a timed override command
      f. Available in either surface mount, wall mount, or flush mount
      g. Available with either screw terminals or phone jack

D. VAV Box Controller (VBC)
   1. The VAV Box Controller (VBC) shall provide both standalone and networked DDC of pressure independent, VAV terminal units.
   2. The VBC controller shall be a fully programmable, digital controller that communicates via BACnet IP protocol.
      a. The VBC shall support BACnet Standard ANSI/ASHRAE 135.
         1) The VBC shall be BTL listed/certified.
         2) The VBC shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).
         3) A BACnet Protocol Implementation Conformance Statement shall be provided for the VBC.
   3. The VBC shall include 14 preloaded single duct VAV box control applications to allow the VBC to be made fully operational without the need to create a custom program.

4. The VBC shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
5. The VBC shall be programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
6. The VBC shall be assembled in a plenum-rated plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.
    a. The VBC shall include an integral real-time clock and support time-based tasks which enables these equipment controllers to monitor and control schedules, calendars, alarms, and trends
7. The VBC can continue time-based monitoring when offline for extended periods of time from a network.
8. The VBC shall include an integral differential pressure transducer and damper actuator. An additional configuration option shall be available that also includes an integral potentiometer for actual damper position feedback. All components shall be connected and mounted as a single assembly, removable as one piece.
9. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 60 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
10. The VBC shall determine airflow by a state-of-the-art, digital, non-flow pressure sensor that supports automatic correction for polarity on high- and low-pressure DP tube connections to eliminate high- and low-pressure connection mistakes.
11. The VBC shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
12. The VBC can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.
13. The VBC shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.
14. The VBC shall have the ability to transfer and apply firmware files to all SA Bus devices (EOIM, IOM, and Networked zone sensors) connected to it.
15. The VBC shall include removable screw terminal blocks for all I/O, FC and SA Bus communication, and power wiring connections.
16. The VBC shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.
    a. Inputs – 24-bit analog-to-digital converter
    b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
17. The VBC shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:
    a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
    b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
    c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
    d. Binary Outputs – 24 VAC Triac
    e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output
18. The VBC shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.
19. The VBC shall have the capability to execute VAV box control sequences involving direct wired I/O points as well as input and output devices communicating over the SA or FC buses.
20. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.

21. Each controller shall continuously adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
22. The controller shall provide the ability to download and upload VAV box control application configuration files, both locally and via the FC Bus. Controllers shall be able to be loaded individually or as a group.
23. Control setpoint changes initiated over the network shall be written to VBC non-volatile memory.
24. The VBC controller firmware shall be flash-upgradeable remotely via the FC bus.
25. The VBC controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
26. The VBC controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
27. The VBC controller shall have on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VBC shall calculate Exponentially Weighted Moving Averages (EWMA) for each of the following metrics, which shall be available to the end user for efficient management of the VAV terminals.
28. The controller shall detect system error conditions to assist in managing the VAV zones.
29. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VBC would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.
30. The VBC controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality) and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.
31. The VBC controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

2.14 LABORATORY CONTROL SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide laboratory control system by one of the following:
   1. Critical Room Control
   2. Phoenix Controls; Honeywell International Inc.
   3. Siemens Industry, Inc.
   4. Triatek; Johnson Controls

B. The Laboratory Control System (LCS) shall be furnished and installed under this section. The LCS shall be fully integrated with the Building Automation System (BAS) to maintain laboratory room supply and exhaust airflows, room ventilation rates, room ambient temperatures & humidity, and the system functionality as specified herein.

C. The LCS shall include all laboratory room supply and exhaust airflow terminals, fume hood (containment) airflow terminals, reheat coils, reheat coil valves, air terminal actuators, sensors, associated instrumentation and the control units and associated interconnecting wiring and pneumatic tubing. Any and all associated components required to implement a fully functioning and integrated system as specified herein shall also be provided. System verification and other documentation as specified under the Sections referenced herein shall also be included.

D. Performance and Design Criteria
   1. Each laboratory shall have a dedicated LCS. Each dedicated LCS shall support a minimum of 20 network-controlled airflow devices.

2. The LCS shall use volumetric offset control (airflows determined during TAB) to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement, vortex shedding measurement, or velocity measurement to control room pressurization are unacceptable.
3. The LCS shall maintain specific airflow (±5% of signal) with a minimum turndown as specified to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.
4. Airflow Control Sound Specification
    a. The LCS manufacturer shall provide comprehensive sound power level data for each size airflow control device. All data shall be obtained from testing in accordance with ASHRAE/ANSI Standard 130, Methods of Testing Air Terminal Units.
    b. All proposed airflow control devices shall include discharge, exhaust, low pressure shutoff, and radiated sound power level performance.
    c. If the airflow control device cannot meet the sound power levels required to achieve the sound criteria appropriate for the space, as determined by the engineer, a properly sized sound attenuator must be used. All sound attenuators must be of a packless design (constructed of at least 18-gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20 inches of water.

E. Control Functions
1. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, temperature, and humidity control, as well as respond to occupancy and emergency control commands. Laboratory space controllers, PLC's, or room controllers utilizing analog control of general exhaust, hood, and supply valves are not acceptable.

F. Interface to Building Automation System
1. The LCS network shall have the capability of digitally interfacing with the BAS. The required software interface drivers shall be developed and housed in one or more dedicated interface devices furnished by the LCS supplier.
2. All room-level points shall be available to the BAS for monitoring or trending. The LCS Integrator and/or Room Manager shall maintain a cache of all points to be monitored by the BAS. The room-level airflow control devices shall update this cache continually.
3. The Room-level network shall be BACnet communications protocol.
4. Room Level Integration
    a. The room level integration device shall be standalone piece of hardware and will be used for commissioning and configuration of venturi valves and ancillary components such as Input Output (I/O) modules.
    b. If the room level integration device drops off the network or loses power, it shall not cause the zone balance, temperature control, or fume hood devices to lose control. The room level valve devices should operate independently of the room level integration device.
    c. Room Level Integrator shall be able to integrate to BAS and shall be through BACnet/IP, through on board communication adapters and shall be field configurable/upgradable.
5. Room Manager
    a. For buildings that require a single IP address to interface to the Building Automation system (BAS), Valves and Ancillary components is necessary, a Room Manager shall be provided. The Room Manager shall house the database wherein all the configurable inputs and outputs will reside, will provide a single BACnet IP port to be used to connect to the BAS system, will provide a means to access all the valve and fume hood display configuration data, input/output module programming, diagnostic views, Lab Verification tools, as well as a central location to back up all the

configuration data, valve characterization data, and balancing reports as generated from the Phoenix Controls Lab Verification Tool.

6. LCS critical environment integration shall support distributed network architecture from room level BACnet MS/TP segment to a dedicated BACnet/IP building backbone using single or multiple IP addresses. Backbone communication protocol must be field selectable/upgradable.
7. Communication between devices in a room or zone will operate independent of building level communications maintaining integrity of the airflow. LCS Building level communication, or loss of, will not disrupt the communication between devices in a room or zone.
8. LCS critical environment integration shall provide optional software to manage local backup and restore, entire site device management, building wide test and balance functions, building wide diagnostic tools, and building wide configuration tools. Software shall be field upgradable to support graphical dashboard displays.

G. Airflow Device Controller - Exhaust and Supply
1. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
2. During normal operation the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:
   a. 60 seconds for standard speed actuation (90 seconds from shutoff to max flow and vice versa).
3. The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room- level digital airflow control devices using an industry standard protocol.
4. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no separate room-level controller shall be required.
5. The airflow control device shall use industry standard 24 VAC power.
6. The airflow control device shall have provisions to connect a Phoenix Controls Workbench (WKB100) commissioning tool and every node on the network shall be accessible from any point in the system.
7. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
   a. Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
   b. One digital input capable of accepting a dry contact or logic level signal input.
   c. Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
   d. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.
8. The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
9. The airflow control device shall be ROHS compliant.

H. Airflow Control Valves – General
1. Basis-of-Design Product: Subject to compliance with requirements, provide Phoenix Controls Celeris Accel II pressure independent venturi valve or comparable product by one of the following:
   a. Critical Room Control
   b. Phoenix Controls; Honeywell International Inc.
   c. Siemens Industry, Inc.
   d. Triatek; Johnson Controls

2. The valve assembly manufacturer’s Quality Management System shall be registered to ISO 9001:2008.
3. Airflow control device shall be OSHPD tested and certified per IBC, ASCE 7-10, and ICC-ES-AC-156.
4. The airflow control device shall be mechanically pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change (within product specifications) or quantity of airflow controllers on a manifolded system.
    a. The airflow control device shall maintain accuracy within ±5% of signal to set point over an airflow turndown range of no less than 5 to 1.
    b. A “low” range spring shall deliver pressure-independent flow control as long as the pressure drop across the air valves stays within the range of 0.3 in. WC to 3.0 in. WC.
    c. The spring shall respond in less than 1 second to changes in static pressure.
    d. Air valves shall be factory calibrated with NIST traceable flow stations.
5. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
6. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence.
7. The airflow control device shall maintain pressure independence regardless of loss of power.
8. Airflow control devices utilizing ASHRAE 130 minimum operating pressure as a rating for minimum design pressure at required flow will not be acceptable on basis on minimum operating pressure alone. Valve manufacturer will provide minimum required differential pressure in writing for each size valve they offer.
9. Airflow control device shall be able to achieve its maximum turndown ratio at its stated minimum operating differential pressure. Devices that require duct static pressure to be increased to achieve maximum flow shall not be acceptable.
10. The airflow control devices shall be constructed of the following:
    a. Class A—The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum.
        1) The device's shaft and internal “S” link shall be made of 316 stainless steel.
        2) The shaft support brackets shall be made of 316 stainless steel.
        3) The pivot arm shall be made of 303/304 stainless.
        4) The pressure independent springs shall be a spring-grade stainless steel.
        5) All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite.
        6) Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction.
        7) No sound absorptive materials of any kind shall be used.
    b. The airflow control device for corrosive airstreams, such as fume hoods, shall have a baked-on, corrosion-resistant phenolic coating.
        1) The device's shaft shall be made of 316 stainless steel with a Teflon coating.
        2) The shaft support brackets shall be made of 316 stainless steel.
        3) The pivot arm and internal “S” link shall be made of 316 or 303 stainless steel.
        4) The pressure independent springs shall be a spring-grade stainless steel.
        5) The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene) or PPS (polyphenylene sulfide) composite.
    c. Note: Airflow Control Devices utilizing vortex shedding sensors and installed in fume hoods or corrosive environments MUST be constructed with Stainless steel bodies and MUST have stainless steel Vortex Shedding sensors. PolyCarbonate Vortex Shedding sensors will NOT be acceptable in corrosive environments.
11. Actuation

a. For high speed actuated VAV operation, the following actuator shall be factory mounted to the air valves. The failsafe state for high speed operation valves shall be fail-closed, expect for actuators serving fume hood air valves which shall fail-open.
    1) Actuator Type = High speed electrically actuated VAV operation, a CE certified, UL Listed, IP56 rated for dust and water, linear electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state.
        a) Options for these failsafe states include: normally open– (maximum position), normally closed– (minimum position), and fail-to-last position.
        b) This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).
b. In fail safe conditions the airflow control device shall remain pressure independent and in control of airflow at its failed position; i.e. if a device fails in position at 500 cfm, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 500 cfm at that given control point regardless of duct pressure (within product specifications). Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.
c. During normal operation, the high-speed linear actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less. Full stroke time shall be less than 3 seconds from shutoff to full open, or from full open to shutoff.
d. Constant volume valves shall not require actuators.

12. The controller for the airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network. The room-level control network shall utilize a BacNET communications protocol.
13. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, standard and advanced temperature control, humidity control, and implement occupancy and emergency mode control schemes. A Room controller or PLC performing these functions shall not be acceptable.
14. The LCS shall digital integration with the BAS. If digital integration device, room controller, laboratory space controller or similar is lost or offline or fails then the valve controllers shall have distributed controllability and will keep the basic room functions of zone balance, temperature, humidity control, offset control, etc. operating to maintain a safe and comfortable zone.
15. NVLAP Accreditation (Lab Code 200992-0)
    a. Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.
    b. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined uncertainty of no more than
    c. ±1.4% of signal (4,200 to 250cfm), ±2.5% of signal (249 to 100cfm) and ±4% of signal (199 to 35cfm). Electronic airflow control devices shall be further characterized and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.
    d. Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.

I. Shutoff Airflow Control Device
   1. Shutoff air flow device shall be low leakage shutoff (with gasket).
   2. The shutoff airflow control device shall have shutoff leakage and casing leakage of no greater than the following (with 5.0” WC static pressure):
      a. Low leakage shutoff devices up to 850 CFM: 0.005 CFM
      b. Low leakage shutoff devices up to 1,300 CFM: 0.010 CFM

J. Two-Position Exhaust Airflow Control Device
   1. The airflow control device shall maintain a factory characterized fixed maximum and minimum flow set point based on a remote contact/sash switch for electronic valves or a switched 0 to 20 psi pneumatic signal for pneumatic valves.
   2. Two-position devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.
   3. All two-position devices shall be either networked or hard-wired into the room-level network to be considered under pressurization control.

K. Constant Volume Airflow Control Device
   1. The airflow control device shall maintain a constant airflow set point. It shall be factory characterized and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.
   2. Constant volume valves must be 100% mechanically pressure independent and require no actuation to maintain set point.
   3. Constant volume valves shall have no required electronics to maintain set point.

L. Local Display Unit
   1. The control system shall have a local display option that allows monitoring and control of system variables to be displayed on a user interface terminal device.
   2. The display unit shall be a touch screen monitor that shall connect to the room level devices through a room controller or room integrator.
   3. The display unit shall be powered by 24 VAC.
   4. The local display unit shall have the provisions of being flush mounted or surface mounted directly to a standard electrical enclosure. Electrical conductors shall terminate inside the display module housing to a pluggable terminal block.
   5. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down and general cleaning agents.
   6. The unit’s exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride/ hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
   7. The display unit shall be rated for use in areas where IP54 rating is required.
   8. The display unit shall utilize a 7” diagonal touchscreen display with optional color schemes to adapt the display to various lighting conditions.
   9. The display unit shall provide a means of entering and displaying a unique location descriptor (device ID).
   10. The display unit shall allow access to pertinent flow, temperature, humidity, pressure data, as well as occupancy and emergency mode control status, and current device or system alarm status. Data shall be viewable in units of measure appropriate for users of the system.
   11. The display unit shall have the ability to display up to 48 parameters, on two screens organized into display screens of up to 6 tiles, and up to 4 points per tile (24 parameters per page and up to 2 pages).
      a. Present value, which may be read directly off the network, or conditioned with a fixed multiplier and/or offset to scale the value for the desired units of measure.
      b. Units of measure, which are configurable based on local user conventions.
   12. Set points and editable control parameters shall be viewable on the View. The user shall have the ability to provide four levels of access. There will be three levels of PIN code access to prevent unauthorized changes to set points and editable control parameters.
   13. Monitor shall have the ability to locally display alarms for:

a. Numeric High and Low limits
b. Binary inputs (alarm selectable for True or False state)
c. Multistate alarms (alarmable on all but one state)

14. Alarms shall have adjustable volume and the ability to be muted for situations where a visual alarm is acceptable or an audible alarm is not desired.

M. Control valves: As specified elsewhere under this Section.

N. Sensors and Binary Devices: As specified elsewhere under this Section.

O. Miscellaneous Control Devices: All other control devices not specifically identified under Laboratory Control System shall meet specific item requirements listed elsewhere under this Section.

P. Reheat Coils: Laboratory supply terminal units shall be provided with a hyronic reheat coil. The control of the reheat coil shall be in conjunction with the terminal unit control. The terminal unit controller shall be responsible for the control of the reheat coil.

Q. Installation
1. The BAS contractor shall install all room controllers and room integrators in an accessible location in or around the designated laboratory room.
2. The BAS contractor shall terminate and connect all cables as required. In addition, integrated laboratory control unit connectors shall be furnished by the BAS contractor.
3. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.
   a. Provide at the inlet at least one equivalent diameter of straight duct, or a transition with less than 30-degree taper.
   b. Adjoining ductwork shall be supported within 12” of the air valve.
   c. Allow minimum 18” clearance from enclosure door and/or actuator for service.
4. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.
5. The mechanical contractor shall provide and install all reheat coils, neutralizers, silencers, and transitions.
6. The mechanical contractor shall provide and install insulation as required.
7. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect. Provide 120-volt power in the laboratory ceiling spaces for connection to the laboratory control system equipment and/or where indicated on Division 26 drawings. Provide 24 VAC power where required by the LCS and associated control devices.
8. Air Valves, Reheat Coils and Control Valves
   a. Furnish all laboratory air terminals, reheat coils (if separate from the air terminal) and control valves for installation.
   b. Actuators shall be mounted on the same side of air terminals as coil connections to ensure service access
   c. Access door shall be provided at inlet side of coil.
9. Fume Hood Controls
   a. Coordinate all requirements with the fume hood manufacturer.
   b. Furnish templates to the fume hood manufacturer for any devices requiring fume hood mounting. Fume hood manufacturer shall provide necessary cut outs with blank cover plates.
   c. Verify any sash sensor requirements with the fume hood manufacturer based on fume hood size, sash configuration and installation requirements for each device.
   d. Install, mount and wire required hood mounted devices.
10. Occupancy Sensors
   a. Where applicable or required by the sequence of operations, install sensors to provide full coverage of the intended space.

R. LCS System Checkout and Testing

1. System startup shall be provided by factory certified and trained employees of the LCS manufacturer. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration. Startup shall include the following tasks:
   a. Determine when the HVAC equipment and each room is ready for ventilation system operational testing.
   b. Furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
   c. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
   d. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules.
   e. Alarms and Interlocks:
      1) Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
      2) Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
      3) Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
   f. Set up all laboratory room controllers and verify that all controlled parameters are being maintained at the required setpoint and that all associated operational aspects including measurement accuracies, alarm criteria, high-low limits, time delays, etc. are functioning in accord with the specified performance. The Testing Adjusting and Balancing (TAB) contractor shall verify that all airflows are within the specified requirements and any departure from the specified performance shall be corrected and verified by the LCS to ensure all aspects of the control system are in full conformance with these specifications. The setup and verification process shall cover:
      1) Fume hood face velocity and/or fume hood exhaust airflow rate control.
      2) Fume hood high and low alarms
      3) Room supply and exhaust airflows and the room ventilation rate control
      4) Room static pressurization control and associated operational criteria.
      5) Room ambient temperature control
      6) Room/zone humidity control
      7) Room emergency control sequences
      8) Laboratory facility centralized exhaust system static pressure, exhaust stack velocity and associated exhaust system functionality
2. All operational aspects of the LCS performance shall be formally recorded when verified and a copy of the recorded data shall be provided to the owner as part of the as-built documentation.

S. Building Automation System Interface
   1. All points shall be provided to and from the BAS.
   2. Define space temperature alarming setpoints.
   3. Information shall be communicated by seamless LAN connections.

T. LCS System Demonstration and Acceptance
   1. Demonstration
      a. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
      b. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests.

The engineer shall be notified at least 10 days in advance of the start of the testing procedures.

c. The demonstration process shall follow that approved in “Submittals.” The approved checklists and forms shall be completed for all systems as part of the demonstration.

d. The LCS supplier shall provide a functional demonstration on the LCS operation to owner designated representatives as well as other interested participants which may include the architect, engineer, as well as the general and mechanical contractors. This demonstration shall include any LCS control sequences selected by the owner’s representatives and may cover several laboratory rooms. Demonstration items that may be included (but not limited to) shall include fume hood and room airflow control, room pressurization control, exhaust system functionality, emergency functions and associated local monitoring provisions as well as required BAS monitoring and alarm reporting. The day for this demonstration shall be established by the owner’s representatives in conjunction with the other participants.

U. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved.

V. Training

1. The LCS contractor shall provide on-site instruction for up to six (6) owner designated personnel covering all aspects of the operation and use of the LCS including operator interface, control parameter setpoint adjustment, alarm limit and time delay adjustments, point trending, automatic startup, shutdown, and changeover scheduling as well as the manipulation and utilization of all associated LCS monitoring and control functions. The training shall be augmented with an operational manual for each attendee and shall also include the recommended procedures to verify the proper functioning of the LCS. Instructors shall be highly qualified factory trained personnel who reside at the local branch office of the LCS supplier and who are thoroughly familiar with all aspects of the overall subject matter and this specific facility's LCS. All training shall be provided on weekdays during the normal daytime working hours of the facility operations personnel.
2. Training shall consist of not less than eight (8) hours for designated personnel.
3. Additional specialized operational training courses shall be made available to facility personnel covering the LCS and its components.

2.15 INPUT DEVICES

A. Binary Temperature Devices.

1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, (55°F–85°F) setpoint range, 2°F maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, (55°F–85°F) setpoint range, (2°F) maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

B. Temperature Sensors.

1. Sensor range: When matched with A/D converter of controller, sensor range shall provide a resolution of no worse than 0.3°F (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.
2. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph directly above.
    a. Sensor probe shall be 316 or 304 stainless steel.
    b. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3°F accuracy at calibration point.
    c. Liquid Immersion Temperature Sensor shall include brass thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15 °F.
    d. Sensing element (chilled water/glycol systems) shall be thermistor or platinum RTD ±0.5°F measured at 32 °F.
3. Room Temperature Sensor: Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:
    a. Sensing element shall be platinum RTD, thermistor, or integrated circuit, ±1.0°F accuracy at calibration point.
    b. Provide setpoint adjustment with an adjustable range. See drawings for values. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS. This shall be a momentary contact closure. Provide nominal heating and cooling setpoints to maintain heating at cooling setpoint minus 5°F dynamically adjusted as the setpoint is adjusted by user.
    c. Display shall provide LCD indication of space temperature and setpoint.
    d. Provide time over-ride button.
    e. Where indicated on drawings or required for the sequence of operation, provide integral occupancy sensors utilizing Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.

C. Matched Sensors: The following applications shall require matched sensors:
    1. Hydronic Temperature Difference Calculations: Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants. Sensing element shall be platinum RTD guaranteeing an accuracy of ±0.5% of span plus 0.3°F.
    2. Air Handling Unit Sequencing: Provide matched pair for the cooling and heating coil leaving sensors where the sequence includes calculating an offset from the supply air setpoint to maintain a leaving heating coil temperature. Sensing element shall be platinum RTD guaranteeing an accuracy of ±0.5% of span plus 0.3°F.

D. Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three-square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.
    1. Sensing element shall be platinum RTD ±0.3°F accuracy at calibration point.

E. Outside Air Sensor: Shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated.
    1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, sensor range shall provide a resolution of no worse than ±0.1 °F measured at 40°F.

F. Humidity Transmitters:
    1. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change

humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:

2. Input Range: 0 to 100% RH.
3. Accuracy (% RH): ±2% (enthalpy calculation, dew point calculation or humidifier control) or ±3% (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
4. Sensor Operating Range: As required by application
5. Long Term Stability: Less than 1% drift per year.
6. Acceptable Manufacturers: Units shall be Vaisala HM Series, Rotronics, E+E Elektronik, or approved equal.

G. Thermowells
1. When thermowells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
2. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
3. Thermowells and sensors shall be mounted in a threadolet or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.
4. Thermowells shall be constructed of 316 stainless steel.

H. Relays
1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

I. Current Switches
1. Clamp-On or Solid-Core Design Current Operated Switch (for Constant Speed Motor Status Indication)
   a. Range: 1.5 to 150 amps.
   b. Trip Point: Adjustable.
   c. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
   d. Lower Frequency Limit: 6 Hz.
   e. Trip Indication: LED
   f. Approvals: UL, CSA
   g. Max. Cable Size: 350 MCM
   h. Acceptable Manufacturers: Veris Industries H-708/908; Inc., RE Technologies SCS1150A- LED, or approved equal.
2. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication
   a. Range: 1.5 to 135 Amps.
   b. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
   c. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
   d. Frequency Range: 5-75 Hz
   e. Trip Indication: LED
   f. Approvals: UL, CSA
   g. Max. Cable Size: 350 MCM
   h. Acceptable Manufacturers: Veris Industries, Inc. H-904, or approved equal.

J. Current Transformers
1. Clamp-On Design Current Transformer (for Motor Current Sensing)

2. Range: 1-10 amps minimum, 20-200 amps maximum
3. Trip Point: Adjustable
4. Output: 0-5 VDC.
5. Accuracy: ±0.2% from 20 to 100 Hz.
6. Acceptable Manufacturers: Veris H221, KELE SA100 or approved equal

K. Voltage Transformers
1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 40°F–130°F and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

L. Differential Pressure Transmitters
1. General-Purpose Low-Pressure Air: Generally, for each measurement of duct pressure, filter differential pressure or constant volume air velocity pressure measurement where the range is applicable.
   a. General: Loop powered two-wire differential capacitance cell-type transmitter.
   b. Output: two wire 4-20 mA or 0-5 volt for runs less than 100’ output with zero adjustment.
   c. Overall Accuracy: ±1%.
   d. Minimum Range: 0.1 in. w.c.
   e. Maximum Range: 10 in. w.c.
   f. Housing: Polymer housing suitable for surface mounting.
   g. Acceptable Manufacturers: Units shall be Modus T30, Veris PX Series, or Dwyer Series 616. Substitutions shall be allowed per Division 1.
   h. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A- 301 and connecting tubing.
   i. Range: Select for specified setpoint to be between 25% and 75% full-scale.
2. General Purpose Low Pressure/Low Differential Air: Generally, for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.
   a. General: Loop powered, two-wire differential capacitance cell type transmitter.
   b. Output: Two-wire 4-20 mA or 0-5 volt for runs less than 100’ output with zero adjustment.
   c. Overall Accuracy: ±1%.
   d. Minimum Repeatability: ±0.25% of reading
   e. Maximum Range: 0.1, 0.25, or 0.5 in. w.c.
   f. Housing: Polymer housing suitable for surface mounting.
   g. Acceptable Manufacturers: Modus T30. Substitutions shall be allowed per Division 1.
   h. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A- 301 and connecting tubing.
   i. Range: Select for specified setpoint to be between 25% and 75% full-scale.

M. VAV Velocity Pressure: Generally, for use in variable volume air velocity pressure measurement where the range is applicable.
1. General: Loop powered two-wire differential capacitance cell type transmitter.
2. Output: Two-wire, 4-20 mA output with zero adjustment.
3. Overall Accuracy: ±0.25%
4. Minimum Range: 0 in. w.c.
5. Maximum Range: 1 in. w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Setra or Approved Equal or approved equal.
8. Range: Select for minimum range that will accept the maximum velocity pressure expected.

N. Differential Pressure Switches

1. General Service Auto Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing.
    a. Acceptable Manufacturer - Dwyer Series 1900 or equal.
2. General Service Manual Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing.
    a. All manual resets shall be readily accessible, capable of being reached quickly without requiring those to whom ready access is requisite to actions such as to use tools, to climb over or remove obstacles, or to resort to portable ladders.
    b. Acceptable Manufacturer - Dwyer Series 1900 or equal.
3. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range and 0°F to 160°F operating temperature range.

O. Pressure Switches
1. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.
2. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls or approved equal.

P. Air Filter Status Switches
1. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
2. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
3. Provide appropriate scale range and differential adjustment for intended service.

Q. CO2 Sensors/Transmitters (CO2)
1. CO2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
    a. Accuracy: ±25ppm at 800 ppm and 68 °F.
    b. Stability: 5% over 5 years.
    c. Output: 4-20 mA, 0-10 Vdc or relay.
    d. Mounting: Duct or Wall as indicated.
    e. Automatic Background Calibration capable
    f. Calibration Kit – Provide 1 calibration kit for a project that contains at least 1 CO2 sensor. Kit shall include 2 CO2 calibration gas cylinders; one 200 ppm and one 1000 ppm, gas regulator, tubing, and fittings, adapters, sensor cones etc. for the application.

R. Air Flow Monitoring - Fan Inlet Airflow Measuring Station (AFMS)
1. Basis-of-Design Product: Subject to compliance with requirements, provide Ebtron Model GTx108-F or a comparable product by one of the following:
    a. Tek-Air Systems or equal
2. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
    a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
    b. Vortex shedding airflow measurement devices, pitot tubes, pitot arrays, piezo-rings and other differential pressure measurement devices are not acceptable.
3. General
    a. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature of each fan within the fan array at each measurement location.
    b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.

1) Devices that have electronic signal processing components on or in the sensor probe are not acceptable.

c. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.
1) Actual airflow rate calculations shall have the capability of being field adjusted by the transmitter for altitudes other than sea level.

d. Temperature output shall be field configurable to provide either the velocity-weighted duct average temperature or simple arithmetic average temperature.

4. Sensor Probes
a. Each sensor probe shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
b. Sensor node internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
c. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392°F and continuous and direct UV exposure.
1) Plenum rated PVC jacket cables are not acceptable.

d. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
e. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
f. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.
1) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.

g. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
h. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
i. The number of independent sensor nodes provided shall be as follows:
1) SWSI and DWDI fans: 2 probes x 1 sensor node/per probe in each fan inlet
2) Fan Arrays (2 to 4 fans):
a) 2 probes x 1 sensor node per probe in each fan inlet
3) Fan Arrays (5 to 8 fans): 1 probe x 1 sensor node per probe in each fan inlet.

5. Transmitter
a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
c. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
e. All receptacle plug pins shall be gold plated.
f. The transmitter shall be capable of determining the average airflow rate and temperature of each fan.
1) Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).

g. The transmitter shall have startup firmware to facilitate setup of multiple fans and fan areas.
h. The transmitter shall be capable of providing a high and/or low airflow alarm.
i. The transmitter shall be capable of providing individual fan alarming on fan array configurations.

j. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
k. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
   1) The total airflow rate, temperature, airflow alarm, individual fan alarm and system status alarm shall be visible on the display.
l. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and either:
   1) one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection; or
   2) one isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection.
m. Analog signal capability shall include two output terminals: the first, shall provide the total airflow rate; while the second output shall be field configurable to provide one of the following:
   1) temperature
   2) airflow alarm
   3) individual fan alarm; or
   4) system status alarm
n. Network communications shall provide: the total airflow rate, average temperature, individual fan airflow rates, individual fan temperatures, airflow alarm, individual fan alarm, system status alarm, individual sensor node airflow rates, individual sensor node temperatures and fan inlet area.
o. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
p. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.
q. Display location shall be readily accessible and capable of being read from the floor, without requiring portable ladders.

6. Performance
   a. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 10,000 FPM.
      1) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
         a) Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
   b. Each sensing node shall have a temperature accuracy of ±0.15° F over an operating range of -20° F to 160° F°.
7. EB-Link Bluetooth Interface for Android® and iPhone®:
   a. Included capability to download individual sensor node airflow/temperature data, settings and diagnostics.
8. Install in accordance with manufacturer’s placement and installation guidelines.

S. Air Flow Monitoring – Duct Mounted
1. Basis-of-Design Product: Subject to compliance with requirements, provide Ebtron Advantage IV Gold Series for use with GTx116 transmitters or a comparable product by one of the following:
   a. Tek-Air Systems or equal
2. Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.
   a. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
   b. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

c. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
d. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
e. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
f. Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
g. Devices using less than two thermistors in each sensor assembly are not acceptable.
h. Devices using platinum wire RTDs are not acceptable.
i. Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
j. Pitot tubes and arrays are not acceptable.
k. Vortex shedding devices are not acceptable.

3. All Sensor Probes
   a. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
   b. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
   c. Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.
      1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
   d. Temperature accuracy shall be +/-0.15° F over the entire operating temperature range of -20° F to 160° F.
   e. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
   f. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
   g. Each sensor assembly shall not require matching to the transmitter in the field.
   h. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.
4. Duct and Probes
   a. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
   b. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
      1) Insertion mounted through the side or top of the duct
      2) Internally mounted inside the duct or plenum
      3) Standoff mounted inside the plenum
   c. The number of sensor housings provided for each location shall be as follows:
      1) Duct area <2 sq.ft = 4 Total # Sensors
      2) Duct area 2 to < 4 sq.ft = 6 Sensors
      3) Duct area 4 to < 8 sq.ft = 8 Sensors
      4) Duct area 8 to <16 sq.ft = 12 Sensors
      5) Duct area >=16 sq.ft = 16 Sensors
   d. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.
5. Transmitters
   a. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.
   b. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.

c. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).
   1) The transmitter shall use a switching power supply fused and protected from transients and power surges.
   2) The transmitter shall use “watch-dog” circuitry to assure reset after power disruption, transients and brown-outs.
d. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
e. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be installed at a location that is protected from weather and water.
f. The transmitter shall be capable of communicating with other devices using the following interface option: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4- wire)
g. Display location shall be readily accessible and capable of being read from the floor, without requiring portable ladders.

6. The transmitter shall be capable of accepting an infra-red interface card for downloading airflow and temperature data or uploading transmitter configuration data using a handheld PDA (Palm or Microsoft Windows Mobile operating systems).
   a. Provide PDA upload/download software.
      1) Download software shall be capable of displaying and saving individual sensor airflow rates, the average airflow rate, individual sensor temperatures and the average temperature received from the transmitter.
      2) Upload software shall be capable of displaying and saving all setup parameters that can be configured using the on-board pushbutton interface and LCD display.
7. EB-Link Bluetooth Interface for Android® and iPhone®:
   a. Included capability to download individual sensor node airflow/temperature data, settings and diagnostics.
8. The ATMD shall be UL listed as an entire assembly.
9. The ATMD shall carry the CE Mark for European Union shipments.
10. The manufacturer’s authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.

T. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley or approved equal.

U. Low Temperature Detector (‘Freezestat’) (FZ): Low temperature detector shall consist of a ‘cold spot’ element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8" x 20' (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPDT (4 wire, 2 circuit) with manual reset. Temperature range 15 to 55°F, factory set at 35°F.

V. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
2. AC coil pull-in voltage range of +10%, -15% or nominal voltage.
3. Coil sealed volt-amperes (VA) not greater than four (4) VA.
4. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
5. Pilot light indication of power-to-coil and coil retainer clips.
6. Coil rated for 50 and 60 Hz service.
7. Acceptable Manufacturers: Relays shall be Potter Brumfield, Model KRPA or approved Equal.
8. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC. Substitutions shall be allowed per Division 1.

9. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
10. All safety circuits shall be installed to operate individual interposing relays located in the associated equipment control panel. Each safety device (i.e. Freezestat, DP safety, smoke detector, firestat, etc.) wiring circuit shall be installed with individual homeruns back to the associated control panel. See control drawings for details.

W. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse or approved equal.

X. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall have replaceable fuses in accordance with the NEC. Transformer shall be proper size for application and mounted in minimum NEMA-1 enclosure. Transformers shall be UL Listed Class 2 type with 120 VAC primary, 24 VAC or VDC secondary. Transformers shall be sized so that the connected load does not exceed more than 75% of the manufacturer's stated rating.
1. Transformers shall be manufactured by Westinghouse, Square 'D', or Jefferson or approved equal.

Y. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.
1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
2. TDRs shall be UL and CSA listed, Crouzet type or approved equal.

Z. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley or approved equal.

AA. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley or approved equal.

2.16 CONTROL VALVES

A. All modulating control valves shall be of the "pressure independent" type configured with one integrated valve body that incorporates one chamber with an adjustable Cv and a separate pressure regulating chamber used to maintain a constant differential pressure across the control surface.

B. Ball Valves, 1/2 through 2 in.:
1. Ball Valves shall have forged brass bodies.
2. Valves shall have available either Chrome Plated Brass Balls or 300 Series Stainless Steel Balls in all sizes.
3. Valves shall have available either Nickel Plated Brass Stems or 300 Series Stainless Steel Stems with a blow-out proof stem design in all sizes.
4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
5. Stem seals shall be double EPDM O-rings.
6. Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psid maximum differential pressure and shall be inserted against the casting of the valve.
7. All ball valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 203°F (95°C) fluid temperature.
8. All ball valves with sweat end connections or press end connection shall be rated to 300 psig maximum static pressure at 203°F (95°C) fluid temperature.
9. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.

10. Ball Valves with stainless steel balls and stems shall be rated for use with 15 psig saturated steam.
11. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
12. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
13. Valves shall be maintenance free
14. Valves shall be provided with a 5 year warranty.
15. Valves shall be rated for 200 psid close off pressure.
16. Valve actuators shall be UL-recognized or CSA-certified.

C. Ball Valves, 2-1/2 through 4 in. Flanged:
1. Ball Valves shall have forged brass bodies with ASME Class 150 ductile iron flanges.
2. Valves shall have 300 Series Stainless Steel Balls.
3. Valves shall have 300 Series Stainless Steel Stems with a blow-out proof stem design.
4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
5. Stem seals shall be double EPDM O-rings.
6. Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psid maximum differential pressure.
7. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
8. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
9. All valves shall be rated for service with hot water, chilled water, 50% glycol solutions and rated for use with 25 psig saturated steam.
10. Two-Way Valves shall be rated for 100 psid close off pressure and Three-Way Valves shall be rated for 50 psid close off pressure.
11. Valves shall be maintenance free.
12. Valves shall be provided with a 5 year warranty.
13. Valve actuators shall be UL-recognized or CSA-certified.

D. Butterfly Valves, 2 through 20 in. resilient seat ASME Class 125/150 Flanged:
1. Butterfly Valves shall have cast iron bodies meetings ASTM A126 Class B requirements and meet ASME class 125/150 flange requirements and shall be fully lugged.
2. Butterfly Valves seat shall be Ethylene Propylene Diene Monomer (EPDM).
3. Butterfly Valve disk shall be Ductile Iron with Nylon 11 coating.
4. Butterfly Valve stems shall be Stainless Steel.
5. Flow Characteristics shall be equal percentage up to 70° of disk rotation.
6. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
7. Valves shall be maintenance free.
8. Valve shall be provided with a 3 year warranty.
9. Valve electric actuators shall be UL-recognized or CSA-certified.

E. Butterfly Valves, High Performance 2-1/2 through 16 in.
1. Butterfly Valves shall have bodies manufactured from Carbon Steel, ASTM A216 GR WCB/A516 GR 70 and shall be fully lugged per ASME Class 150 or ASME Class 300.
2. Butterfly Valves seat assembly shall be RPTFE (reinforced polytetrafluoroethylene) and the seat retainer shall be Carbon Steel, ASTM A516 GR 70
3. Butterfly Valve disk shall be Stainless Steel, ASTM A 351 GR CF8M
4. Butterfly Valve stems shall be 17-4 PH Stainless Steel, ASTM A564-Type 630
5. Butterfly Valve Stem Seals shall be One Carbon Fiber Ring and Three TFE Rings
6. Flow Characteristics shall be equal percentage up to 70° of disk rotation.
7. All valves shall be rated for service with hot water, chilled water, 50% glycol solutions and 50 psig saturated steam in modulating service or 150 psig saturated steam in two position service.
8. Butterfly Valves shall meet the performance requirements of ASME Class 150 or Class 300.

9. Valves shall be maintenance free.
10. Valves shall be provided with a 3 year warranty.
11. Valve electric actuators shall be UL-recognized or CSA-certified.

F. Globe Valves, Brass, 1/2 through 2 in.
1. Valves shall have bodies manufactured from a RoHS compliant brass.
2. Valves shall meet the pressure and temperature requirements of ANSI B16.15, Class 250
3. Valve stems shall be a 300 Series Stainless Steel.
4. Valves with brass plug and seat shall have stem seals with Self-Adjusting Ethylene Propylene Rubber (EPR) Ring Pack U-Cups
5. Valves with Stainless Steel plug and seat shall valve stem seals with Spring Loaded Polytetrafluoroethylene (PTFE) and Elastomer V-Rings
6. Valves with brass trim shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2, Class 4 and valves with stainless steel trim shall have a maximum leakage of 0.05% of maximum flow
7. Flow Characteristics shall be equal percentage for two-way valves and linear for three-way valves.
8. Valves shall be serviceable without being removed from the pipe.
9. Valves shall be provided with a 3 year warranty.
10. Valve electric actuators shall be UL-recognized or CSA-certified.

G. Globe Valves, Cast Iron, 2-1/2 through 6 in.
1. Valves shall have bodies manufactured from cast iron.
2. Valves shall meet the pressure and temperature requirements of ANSI B16.1, Class 125
3. Valve stems shall be a 316 Series Stainless Steel.
4. Valves shall have stem seals with Ethylene Propylene Terpolymer (EPT) Ring Pack U-Cups
5. Valves shall have a maximum leakage specification of 0.1% of maximum flow per ANSI/FCI 70-2, Class 3
6. Flow Characteristics shall be equal modified linear.
7. Valves shall be serviceable without being removed from the pipe.
8. Valves shall be provided with a 3 year warranty.
9. Valve electric actuators shall be UL-recognized or CSA-certified.

H. Electric Zone Valves, 1/2 through 1-1/4 in.
1. Valves shall have bodies manufactured from Forged Brass.
2. Valves stems shall be brass (Hard Chrome Plated)
3. Valve Actuator shall be UL, cUL listed or CSA certified.
4. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
5. Two Position valves shall have models available rated for use with 15 psig saturated steam.
6. Valve Actuator shall be replaceable without removing valve from the pipe.
7. Modulating Valves flow characteristics shall be equal percentage
8. Valves shall be provided with a 2 year warranty.
9. Valve actuators shall be UL-recognized or CSA-certified.

I. Pressure Independent Valves, 1/2 through 2 in.
1. Valves bodies shall be manufactured from forged brass and shall be nickel plated
2. Valves shall have a stem and ball manufactured from chrome plated brass
3. Valve seat shall be fiberglass reinforced with Teflon®
4. Characterizing disk shall be brass for 1/2 and 3/4 in. valves, and Tefzel® for sizes 1 through 2 in. valves
5. Valves shall pressure ratings of 600 psi for 1/2, 3/4 and 1 in. size valves, and pressure rating of 400 psi for 1-1/4, 1-1/2 and 2 in. size valves
6. Close off Pressure rating shall be 200 psid
7. Valves shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2,
8. Class 4 with a 50 psid differential pressure applied.

9. Valves shall be maintenance free.
10. Valves shall be provided with a 5 year warranty.
11. Valve actuators shall be UL-recognized or CSA-certified.

2.17 CONTROL DAMPERS

A. The BAS Contractor shall furnish all automatic control dampers, unless located within and provided as part of a factory furnished air handling unit. All automatic dampers shall be sized for the application by the BAS Contractor or as specifically indicated on the Drawings.

B. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

C. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

D. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60”. Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil- impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48”x48” size shall not leak in excess of 8.0 cfm per square foot when closed against 4” w.g. static pressure when tested in accordance with AMCA Std. 500.

E. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5” w.g., but no more than 4000 FPM or 6” w.g.
   1. Acceptable manufacturers are Tamko, Ruskin CD50 or CD60, and Vent Products 5650.

F. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.
   1. Acceptable manufacturers are: Tamko, Ruskin CD36, and Vent Products 5800.

G. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

2.18 ELECTRIC DAMPER AND VALVE ACTUATORS.

A. The BAS Contractor shall furnish all damper and valve actuators, including actuators for dampers located within an air handling unit.

B. Damper and valve actuators shall be electronic. Controls submittals shall indicate actuator fail position as normally open or closed.

C. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator’s rotation.

D. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

E. Signal and Range. Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as approved by Engineer.)

F. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

G. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

H. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan.

I. Two-position actuators, as specified in sequences of operations as “quick acting,” shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

2.19 METERS

A. Meter Communication Requirements
   1. Meters shall have the ability to communicate to the EMIS via at least one of the following protocols:
      a. Serial & Ethernet Communications:
         1) BACnet IP
         2) BACnet MS/TP
      b. Analog & Digital Output (with Gateway):
         1) 4-20 mA
         2) 0-10 VDC
         3) Scaled pulse
   2. All metering devices are to be connected to the existing secured data network. WTCC provides the BACnet Device ID # and network, and the IP Address will be set DHCP if possible. If device cannot be set for DHCP then a static address will be provided. The following information must be provided to the WTCC BAS Controls Engineer via the WTCC Project Manager in an excel spreadsheet to add devices to the WTCC network:
      a. Total count of host devices
      b. Locations of host devices
      c. Device Name
      d. Device MAC
   3. Meters and enclosures shall be suitable and rated for the installed environmental conditions.

B. Network Accessibility
   1. Network access is to be coordinated with WTCC BAS Controls Engineer through the WTCC Project Manager.

C. General
   1. All metering equipment shall have a minimum of a 1-year warranty. Refer to specific utility function and meter for more strict warranties.
   2. All device installations (meters and gateways) shall have a minimum parts and labor warranty of 1 year to account for any inconsistencies or discrepancies with this Standard.
   3. Power, where needed, shall be obtained from a dedicated 20 Amp circuit in the nearest local building electrical panel unless otherwise stated. The electrical panel schedule shall be updated in the field. The Panel/Circuit information is to be included in the Controls As-Built and Record Control Drawings.

D. Installation
   1. The meter shall be installed to manufacturers’ guidelines and any questions regarding the installation shall be referred to the local meter representative for confirmation prior to installation.
   2. All meters shall be installed in an easily accessible location that allows for direct and easy reading of a visual display and convenient calibration and maintenance provided the install follows all OEM installation guidelines.
   3. Bypass piping and valving shall be included in the installation of all water and natural gas meters, to allow servicing of inline meters without disruption of service. All heating hot water (HHW) and chilled water (CHW) metering devices, including BTU meters, flow meters and temperature sensors, shall be serviceable without requiring shutdown of associated HHW and CHW systems. Manufacturers required straight run piping must be provided upstream and downstream of all metering devices.

E. Ethernet Gateway

1. If a meter does not have an integrated backlit display, or if it does not have BACnet IP capabilities, it shall communicate through an ethernet gateway device.
2. The preferred gateway device is the Onicon D-100 Flow Meter Display.

F. Electric Power Metering
   1. General
      a. One or more electric sub-meters shall be installed to capture total building electricity data. Multiple sub-meters may be required for specific areas of a building or for specific equipment loads such as HVAC, lighting, etc.
      b. Power meter shall utilize the acceptable communications protocols identified in this specification to transfer data to the EMIS.
   2. Type
      a. The power meter shall be fully electronic with a multi-line backlit display showing measured parameters on a local display.
   3. Measurements and Accuracy
      a. The power meter shall perform, at minimum, the electrical measurements as follows:
         1) Active Power Demand: Precision = 1, kW
         2) Energy Total: Precision = 1, kWh
         3) Frequency: Precision = 2, Hz
         4) Line Voltage AB: Precision = 1, V
         5) Line Voltage BC: Precision = 1, V
         6) Line Voltage CA: Precision = 1, V
         7) Neutral Current: Precision = 1, A
         8) Phase A Active Power: Precision = 1, kW
         9) Phase A Current: Precision = 1, A
         10) Phase A Voltage: Precision = 1, V
         11) Phase B Active Power: Precision = 1, kW
         12) Phase B Current: Precision = 1, A
         13) Phase B Voltage: Precision = 1, V
         14) Phase C Active Power: Precision = 1, kW
         15) Phase C Current: Precision = 1, A
         16) Phase C Voltage: Precision = 1, V
         17) Reactive Power: Precision = 1, kW
         18) Total Active power: Precision = 1, kW
         19) Total Apparent Power: Precision = 1, kVA
         20) Total Power Factor: Precision = 2, pf
      b. The power meter shall perform to the accuracy standards provided by the OEM.
   4. Location and Install Requirements
      a. The meter shall be located in an accessible and readable location, three to five feet above finished floor. Mounting position shall be horizontal.
      b. The meter shall be installed to the manufacturer’s guidelines, accounting for size, amperage and voltage of the measured line.
   5. Manufacturer
      a. Basis-of-Design Product: Subject to compliance with requirements, provide Schneider Electric Square D PowerLogic power meter or comparable product by one of the following.
         1) Schneider Electric Square D PowerLogic Energy Meter
         2) Accuenergy, ACUVIM IIBN Power and Energy Meter
            a) The ACUVIM IIBN shall be paired with the Accuenergy AcuPanel 9100 when CTs are not built into the electrical switchgear enclosure by the switchgear manufacturer.
         3) Electro Industries, Shark 50B/100B Power Meter
   6. Current Transformers (CTs)
      a. The CTs shall be standard 5A secondary and conform to the ANSI Standard accuracy class for metering service of 0.3 or better (revenue metering) with burden B-

0.1 to B-2.0 (with burden equal to or greater than that of the installed meter and any other connected equipment).

b. CTs secondary wiring length shall be minimized. The contractor/engineer shall calculate the additional burden of CT wiring and ensure that the total burden of the meter and associated wiring is within the rating of the CTs at the intended accuracy class of 0.3 or better.

c. CT accuracy class shall be sufficient for use in revenue metering with burden equal to or greater than that of the installed meter and any other connected equipment.

G. Natural Gas Metering

1. General
   a. One or more natural gas sub-meters shall be installed to capture total building natural gas consumption and flow.
   b. Meter shall have a visual display of measured values and if not, shall be paired with a network communication device with a backlit visual display along with BACnet network communication capabilities.
   c. The natural gas meter shall be selected based upon the diameter of the line, operating pressure, temperature, mass, and volume requirements of the measured gas line.
   d. The required enclosure for the meter shall be rated for the environmental conditions it will be exposed to (interior and exterior).
2. Type
   a. The natural gas sub-meter shall utilize thermal dispersion or Coriolis technology that is temperature and pressure compensated according to the specifics of the line that is being metered.
   b. Basis of design for the natural gas meter shall be an insertion or inline thermal mass flow meter.
3. Measurements and Accuracy
   a. The natural gas meter shall perform, at minimum, the measurements as follows which are associated with gas meters:
      1) Gas Flow Rate: Precision = 0, cfh
      2) Gas Volume Total: Precision = 0, cf
      3) Gas Temperature: Precision = 1, °F
   b. The natural gas meter shall perform to the accuracy standards provided by the OEM.
   c. The natural gas meter shall be selected with the widest possible turndown to ensure that it can cover all anticipated flow variations for the operational flow of the specified line for the highest degree of accuracy.
4. Location and Install Requirements
   a. The meter shall be located in an accessible and readable location, three to five feet off finished floor if possible. Mounting position shall be horizontal.
   b. Local Display
      1) Flow meters without a digital backlit display for data visualization shall be coupled with a local flow display for viewing captured data metrics and providing additional BACnet network communications capabilities.
   c. The meter shall be installed to the manufacturer's guidelines, accounting for required straight pipe before and after the meter. A flow conditioner may be required to meet these conditions. Any questions regarding installation shall be referred to the local meter representative for confirmation prior to installation.
   d. Required power and mounting shall conform to the manufacturer's recommendations.
   e. Each meter shall be equipped with an identification tag indicating the size, location, model, and serial number for the specified gas line.
5. Manufacturer
   a. Basis-of-Design Product: Subject to compliance with requirements, provide Fox Thermal FT2A Thermal Mass Flow Meter or comparable product by one of the following:
      1) Fox Thermal, FT2A Thermal Mass Flow Meter

2) Endress+Hauser, Proline t-mass F 300 Thermal Mass Flow Meter
3) Onicon, F-5500 Thermal Mass Flow Meter

H. Domestic and Makeup Water
1. General
a. One or more water flow sub-meters shall be installed to capture at minimum total water flow and consumption for the building.
b. Materials which will be wetted shall be made from non-corrosive materials and shall not contaminate water.
c. Include particulate strainer, isolation valves, and bypass lines where necessary.
d. Required power and mounting shall conform to the original equipment manufacturer's recommendations.
2. Type
a. The water meter shall utilize electromagnetic measuring technologies.
3. Measurement and Accuracy
a. The water meter shall perform, at minimum, the measurements as follows which are associated with water meters (DW and MUW):
1) Domestic Water Flow Rate: Precision = 1, gpm
2) Domestic Water Volume Total: Precision = 1, gpm
3) HVAC Make-up Water Flow Rate: Precision = 1, gpm
4) HVAC Make-up Water Flow Total: Precision = 1, gal
5) Chilled Water Make-up Flow Rate: Precision = 1, gpm
6) Chilled Water Make-up Flow Total: Precision = 1, gal
7) Heating Hot Water Make-up Flow Rate: Precision = 1, gpm
8) Heating Hot Water Make-up Flow Total: Precision = 1, gal
b. All water meters will be installed per manufacturer guidelines with sufficient pipe run before and after the flow meter for accurate measurements and perform to the accuracy standards provided by the original equipment manufacturer.
c. The water meter shall be selected with the widest possible turndown to ensure that it can cover all anticipated flow variations for the operational flow of the specified line for the highest degree of accuracy.
4. Location and Install Requirements
a. Meters shall be installed to provide easy access for readings, maintenance, and repairs.
b. Meters shall be flanged and valved when applicable to permit convenient replacement or calibration of metering device.
c. Each flow meter shall be equipped with an identification tag indicating the size, location, model, and serial number for the specified water line.
d. Local Flow Display
1) Flow meters without a digital backlit display for data visualization shall be coupled with a local flow display for viewing captured data metrics and providing additional BACnet network communications capabilities.
5. Manufacturer
a. Basis-of-Design Product: Subject to compliance with requirements, provide Onicon, F-3200/F-3100 flow meter or comparable product by one of the following:
1) Onicon
a) Onicon, F-3200 Inline Electromagnetic Flow Meter
i. F-3200 is the preferred Onicon meter for water (particularly domestic) with low flow parameters. Turndown shall be established at 0.05 feet per second for low end velocity applications.
b) Onicon, FT-3100 Inline Electromagnetic Flow Meter
2) Endress+Hauser
a) Endress+Hauser, Proline Promag 10W Inline Electromagnetic Flow Meter
b) Endress+Hauser, Picomag DMA-series Inline Electromagnetic Flow Meter
3) Badger, M2000 Inline Electromagnetic Flow Meter
4) McCrometer

a) McCrometer, Ultra Mag Inline Electromagnetic Flow Meter

b. The following meters are suggested when physical space is limited for installation:
   1) Endress+Hauser, Picomag DMA-series Inline Electromagnetic Flow Meter
   2) Foxboro, 9500A Inline Electromagnetic Flow Meter
   3) McCrometer, Ultra Mag Inline Electromagnetic Flow Meter

I. BTU Metering (CHW and HHW)
   1. General
      a. A BTU meter shall be installed to measure energy delivered for CHW/HHW applications where a chiller/boiler is providing chilled/heating hot water for multiple buildings on campus to provide the ability to measure the overall energy consumption of each building.
      b. Total building CHW/HHW energy shall be sub-metered to capture at minimum total building BTU/hr and total energy consumption.
      c. BTU meter shall have a visual display of measured variables and if not, shall be paired with a network communication device with a backlit visual display along with BACnet network communication capabilities.
      d. BTU meters shall have a minimum warranty of 2 years.
      e. Required power and mounting shall conform to the original equipment manufacturer's recommendations.
      f. At the express direction of WTCC, building thermal energy may be monitored using standard central plant measurement devices (flow and temperature sensors) with calculations performed in the EMIS software. The data used in such calculations must be trended at 1- minute intervals to ensure accurate energy measurement. It is preferred that a building has a dedicated BTU meter.
      g. BTU meters shall be removable from the piping system without requiring interruption of service or a full size bypass shall be provided with valves to isolate the bypass during normal operation and valves to isolate the meter for removal and service.
   2. Type
      a. The BTU meter shall include a flow meter; two temperature sensors, one for supply and one for return; a BTU processor; and BACnet network communications capabilities.
      b. The BTU meter, flow meter, and temperature sensors shall be from the same OEM and designed to work together for each installed BTU system.
   3. Measurement and Accuracy
      a. The BTU meter shall perform, at minimum, the measurements as follows which are associated with CHW and HHW BTU meters:
         1) CHW/HHW Energy Total: Precision = 0, BTU
         2) CHW/HHW Entering Temp: Precision = 2, °F
         3) CHW/HHW Flow Rate: Precision = 1, gpm
         4) CHW/HHW Leaving Temp: Precision = 2, °F
         5) CHW/HHW Power Rate: Precision = 0, BTU/h
         6) CHW/HHW Volume Total: Precision = 1, gal
      b. The flow meter shall be sized to read at mid-point for the nominal operating system load. The meter shall not be sized for the maximum capacity of the installed system.
   4. Location and Install Requirements
      a. BTU and flow meters shall be installed to provide easy access for readings, maintenance, and repairs.
      b. All BTU meters shall be installed per manufacturer guidelines with sufficient pipe run before and after the flow meter for accurate water measurements.
      c. The required enclosure for the BTU meter shall be rated for the environmental conditions it will be exposed to (interior and exterior).
      d. Each flow & BTU meter shall be equipped with an identification tag indicating the size, location, model, and serial number for the specified meter.
      e. Required power and mounting shall conform to the original equipment manufacturer's recommendations.

5. Manufacturer
    a. Basis-of-Design Product: Subject to compliance with requirements, provide Onicon, System-10 BTU Meter or comparable product by one of the following:
        1) Flexum Flexus F721TE BTU Meter.
            a) Shall include the required temperature sensors for CHW/HHW supply and return temperatures.
        2) Onicon, System-10 BTU Meter
            a) Shall include the required temperature sensors for CHW/HHW supply and return temperatures.
            b) Shall be paired with one of the following Onicon flow meters:
                i. Onicon, F-3200 Inline Electromagnetic Flow Meter
                ii. Onicon, FT-3100 Inline Electromagnetic Flow Meter
                iii. Onicon, F-3500 Insertion Electromagnetic Flow Meter
                iv. Onicon, F-4300 Clamp-On Ultrasonic Flow Meter
        3) Endress+Hauser, EngyCal RH33
            a) Shall include the required temperature sensors for CHW/HHW supply and return temperatures.
            b) Shall be paired with one of the following Endress+Hauser flow meters:
                i. Proline Promag 10W Inline Electromagnetic Flow Meter
                ii. Proline Promag P 300 Insertion Electromagnetic Flow Meter
                iii. Proline Prosonic Flow P 500 Clamp-On Ultrasonic Flow Meter
        4) Badger, FC-5000
            a) Shall include the required temperature sensors for CHW/HHW supply and return temperatures.
            b) Shall be paired with one of the following Badger flow meters:
                i. M2000 Inline Electromagnetic Flow Meter
                ii. Dynasonics TFX-5000 Clamp-On Ultrasonic Flow Meter.

2.20 ENCLOSURES

A. Control equipment panels shall be designed, fabricated and installed in accordance with the codes and standards referenced in this Standard, the project specific requirements (Division 23), and the following:
    1. Enclosures shall facilitate the mounting of gauges, switches, pilot lights, and the like, on the face panel when required. Control devices that are mounted on the face of the panel (e.g. meters) shall be identified with engraved nameplates.
        a. Panels shall be UL508A compliant
    2. All wiring in panels shall be labeled at termination points.
    3. Power Transformers: Step-down power transformers shall be provided for all DDC controllers and associated accessory devices as required. Transformers shall be sized and selected to accommodate all connected accessory items. Transformers shall be UL Listed Class 2 type with 120 VAC primary, 24 VAC or VDC secondary.
    4. Controls wiring: All wiring shall be installed in a neat and professional manner. Control wiring shall not be installed in power circuit conduits or raceways unless specifically approved by the WTCC project manager for that purpose.
        a. Wiring shall be plenum rated cable where concealed and in EMT conduits when exposed.
        b. Wiring in mechanical rooms, electrical rooms, and MDF/IDF rooms shall be in conduit.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that conditioned power supply is available to the control units. Verify that field end devices and wiring are installed prior to installation proceeding.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Verify compatibility with and suitability of substrates.

C. Examine roughing-in for products to verify actual locations of connections before installation.
   1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
   2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

E. Any discrepancies, conflicts, or omissions detrimental to performance of the Work shall be reported to the engineer for resolution before rough- in work is started.

F. The contractor shall examine the drawings and specifications for other parts of the work. If any discrepancies occur between the plans and the contractor's work and the plans and the work of others, the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others.

G. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by, and at the expense of the contractor.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

I. Sequence work to ensure installation of components is complementary to installation of similar components in other systems

J. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units.

3.02 COMMISSIONING REQUIREMENTS

A. Controls system technician responsible for onsite programming checkout shall also provide commissioning support services. Refer to commissioning specifications for additional information.

3.03 WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.04 COORDINATION

A. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section.

B. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.

C. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.

D. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

E. The BAS contractor is responsible for coordinating with and managing the scope of the Master Systems Integrator.

3.05 INSTALLATION

A. Install equipment and devices in accordance with manufacturer's instructions.

B. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

C. BAS Wiring
1. All conduit, wiring, accessories and wiring connections required for the installation of the BAS, as herein specified, shall be provided by the BAS Contractor or his subcontractors. All wiring shall comply with the requirements of the manufacturer as well as local and national electric codes, unless specified otherwise in this section.
2. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.
3. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.
4. All system input wiring shall be twisted shielded pair, minimum 18-gauge wire. All system analog output wiring shall be twisted shielded pair/3-wire as required, minimum 18-gauge wire. Preconfigured cables between Terminal Unit Controllers and Thermostats are acceptable, minimum 24 gauge.
5. All internal panel device wiring for binary outputs and pilot relay shall be minimum 16-gauge wire.
6. All low voltage control wiring and 24VAC wiring shall be installed in conduit.
   a. Conduit shall be installed parallel to the building structural lines.
7. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring. Power wiring 120VAC and greater must be in a separate conduit.
8. All wire insulation shall be labeled with BRADY style markers for ease of identification.
9. Communication wiring shall be provided in a customized color jacketing material. Material color shall be blue and submitted and approved by the Client. In addition, all wiring jackets shall be labeled "BAS" in 3 foot or fewer intervals along the length of the jacket material.
10. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
11. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
12. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.
13. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
14. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as- built) wiring diagrams with terminations identified at the job site.
15. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
16. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
17. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer's instructions.
18. All runs of communication wiring shall be unspliced length when that length is commercially available.
19. All communication wiring shall be labeled to indicate origination and destination data.
20. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

21. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
    a. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
    b. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
    c. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
    d. An MS/TP EIA-485 network shall have no T connections.

D. BAS Raceway
1. All wiring shall be installed in yellow conduit or raceway except as noted elsewhere in this specification.
2. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere. Minimum control wiring conduit size 3/4"
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
5. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.
6. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
7. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.
8. Adhere to Division 26 requirements where raceway crosses building expansion joints.
9. Include one pull string in each raceway 1 in. or larger.

E. Penetrations
1. Provide fire stopping for all penetrations used by dedicated BAS conduits and raceways.
2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

F. Digital Controller Systems:
1. Each system will be provided with its own dedicated BAS controller or application specific controller. Mechanical systems such as AHUs, VAVs or Packaged system shall not be controlled from more than 1 application specific controller.
2. Systems that use second tier controllers as point expansion for system controllers shall only be allowed under when the I/O points are directly controlled by the CPU of the local application specific controller.

G. Input Devices:
1. All Input devices shall be installed per the manufacturer's recommendation. The contractor shall install all in-line devices such as temperature wells, pressure taps, duct smoke detectors, air flow stations, etc.
2. Input flow measuring devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

3. Outside Air Sensors
   a. Sensors shall be mounted on the North wall, out of direct sunlight, to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
   b. Sensors shall be installed with a rain proof, perforated cover.
4. Water Differential Pressure Sensors
   a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
   b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
   c. The transmitters shall be installed in an accessible location wherever possible.
5. Medium to High Differential Water Pressure Applications (Over 21” w.c.):
   a. Air bleed units, bypass valves and compression fittings shall be provided.
6. Building Differential Air Pressure Applications (-1” to +1” w.c.):
   a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
   b. The interior tip shall be inconspicuous and located as shown on the drawings.
7. Duct Temperature Sensors:
   a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
   b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
   c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
   d. The sensor shall be mounted to suitable supports using factory approved element holders.
8. Space Sensors:
   a. Shall be coordinated with Architectural plans and mounted per ADA requirements.
   b. In public areas and/or where indicated on plans, provide sensors without controls interface, and/or a lockable interface.
   c. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate 48 inches above floor, maximum. Align with lighting switches.
   d. Space air temperature sensors shall be provided in all Electrical, AV, IT, Data, Telecom (TR) and Server rooms. Sensors shall be provided with digital display of sensed temperature.
9. Low Temperature Limit Switches:
   a. Install on the discharge side of the first water in the air stream.
   b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
   c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
10. Air Differential Pressure Status Switches:
    a. Static pressure tips, tubing, fittings, and air filter.
11. Water Differential Pressure Status Switches:
    a. Provide with shut off valves for isolation.
12. Do not cover or conceal sensors with insulation.
13. Mount freeze protection thermostats using flanges and element holders. Coil 2 feet minimum of thermostat outside of unit for testing with a glass of ice water.
14. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors.
15. Provide separable sockets for liquids and flanges for air bulb elements.
16. Provide mixing dampers of parallel blade construction arranged to mix streams.

17. Mount control panel in equipment room, adjacent to associated equipment on vibration free walls or free-standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face as hereinafter specification in Article “IDENTIFICATION OF HARDWARE AND WIRING”.
18. Install "hand/off/auto" selector switches in starter face to override automatic interlock controls when switch is in "hand" position.
19. Provide pressure gages with pulsation dampers across domestic water meters. Provide valves to isolate each gage. Extend nipples to allow clearance from insulation.
20. Provide isolation valves around water and gas meter assemblies. Valve types shall be per meter manufacturer recommendation.
21. Provide straight pipe upstream and downstream for all water and gas meters per manufacturer recommendations to achieve maximum accuracy.
22. Thermostats installed on exterior walls shall be provided with insulated backing to avoid impact of cold/hot air on thermostat reading.
23. All pumps and fans shall be provided with a differential pressure sensor installed around the pump or fan. Sensor shall provide status indication for pump or fan operation. Current sensors with VA memory may be used instead of differential pressure sensors where indicated or noted.
24. Adjustable freezestats shall be provided at all heating coils and shall de-energize their respective air handling system when their setting of 37°F is reached. Freezestats for water coils shall be installed in the coil leaving air stream. Freezestats shall be hard wired in the motor starter circuit and send an alarm signal to the BAS when they are activated.
25. All two position dampers and valves shall be proven open by the use of end switches.

H. Output Devices:
1. All output devices shall be installed per the manufacturer’s recommendation. The contractor shall install all in-line devices such as control valves, dampers, etc.
2. Install control units and other hardware in position on permanent walls not subject to excessive vibration.
3. Install software in control units. Implement all features of programs to specified requirements and appropriate to sequence of operation.
4. All output devices shall be installed per the manufacturer’s recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
5. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
6. Control Valves:
   a. Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI.
   b. Install valves in piping with stems as vertical as possible but in no case less than forty-five (45) degrees from vertical. For soldered or welded connections, remove valve internals before installation.
   c. Wire electric valves in accordance with NFPA 70 with not less than two (2) feet of flexible liquidtight connector with watertight bushings at the valve actuator and conduit termination. Brace conduit to the building structure to prevent movement and damage.
7. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Automation is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems..

I. Test and Balance.

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

3.06 CONTROLLERS

A. Provide a separate controller for each AHU. Provide a separate controller for the laborator systems (high plumb exhaust fans, exhaust air valves, etc.).

B. Provide a separate controller for the tertiary water pumps and related equipment in the first-floor mechanical room.

C. Provide a separate controller for the general exhaust fans, building terminal unit controller interface and miscellaneous control points.

D. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

E. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points.

3.07 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Software Programming.
1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
   a. Text-based:
      1) Must provide actions for all possible situations.
      2) Must be modular and structured.
      3) Must be commented.
   b. Graphic-based:
      1) Must provide actions for all possible situations.
      2) Must be documented.
   c. Parameter-based:
      1) Must provide actions for all possible situations.
      2) Must be documented.

3.08 BAS POINT STRUCTURING AND NAMING

A. General
1. Name points consistently across all facilities. Contractor shall configure the systems from the perspective of the entire BAS network, not solely the local project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like. The convention shall be implemented as much as practical, and any deviations from this naming convention shall be pre-approved by the Owner.

B. Point Summary Table
1. Reference WTCC BAS Point Library and WTCC BAS Point Library Schematic documents for point naming requirements.

2. Point Summary Table shall be provided in both hard copy and in electronic format (ODBC-compliant).
3. Point Summary Table shall illustrate Network Variables and Data Link Bindings.
4. The BAS Contractor shall coordinate with the Owner and compile and submit a proposed Point Summary Table for review prior to any object programming or project startup.
5. The Point Summary Table shall be kept current throughout the duration of the project by the Contractor as the Master List of all points for the project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to Final Acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.
6. The Point Summary Table shall contain all data fields on a single row per point. The Point Summary Table is to have a single master source for all point information in the building that is easily sorted and kept up to date. The point description shall be an easily understandable English- language description of the point.

C. Point Naming Convention
1. All point names shall adhere to the format as established in the WTCC BAS Point Library. Said objects shall include all physical I/O points, calculated points used for standard reports, and all application program parameters. For each BAS object, a specific and unique object name shall be required.

D. Limitations
1. Point Name Syntax, Boolean & Enumerated Facets:
   a. Do not use dashes, hyphens, or spaces in the point name, Boolean or Enumerated facets. FIN does not recognize special characters, dashes, hyphens, or spaces as characters.
   b. Use only alphanumeric (A-Z, a-z, 0-9) and underscore (_). Underscores are permitted and may be used in other miscellaneous points not covered in this Point Library Table.
   c. Spaces, hyphens, or special characters (e.g., %, &, ., #, etc) are illegal in component names.
   d. The first character must be a letter (not a numeral).
   e. All point names must be less than 20 characters.
2. Point Names:
   a. Use the point name as written, in camelCase, as identified in this Point Library Table.
3. Point Extensions:
   a. Map extensions to a point: All control values shall be mapped into points for ease of identification. Map control blocks for calculated values (e.g., using the AND / OR blocks) to a point, including any setpoints or values meant to be adjusted by the end user. The goal is that all I/O and logic are available as points, so that, the BAS engineering tool (e.g., Workbench) is not needed for routine operational changes.

E. BACnet Tuning Policy
1. Each point is to be assigned a tuning policy at the building/field controller level.
2. Tuning policies will be applied to each point based on their point type (sensor, sp, cmd):
   a. Sensors are assigned a "fast" policy
   b. Commands are assigned a "medium" policy
   c. Setpoints are assigned a "slow" policy
3. BACnet and Haystack Connectors are also assigned a tuning policy that determine their polling rate. Schedules in FIN are assigned specific "schedule" tuning policies that enable their functionality.
4. BACnet tuning policies must be applied to each point based on these configurations.

F. Device Addressing Convention
1. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.

3.09 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 inches of termination with control system address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum ½ inch letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

E. Identify room sensors related to terminal boxes or valves with nameplates.

F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Identifiers shall match record documents.

H. Field Devices. All field devices shall be identified by a typed (not handwritten) securely attached tag label.

I. Panel Devices. All panel devices shall be identified by a typed label securely fastened to the backplane of the local control panel.

3.10 SOFTWARE LICENSE

A. Supervisory control devices that require software licensing and ongoing service maintenance agreements are expressly prohibited (e.g. N4 JACEs). This prohibition also extends to BAS servers functioning as a building level supervisory controller that require ongoing software licensing or service maintenance agreements (SMAs).

B. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

C. The owner, or his appointed agent, shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configurations and programming that is generated for a given project. Any and all required Ids and passwords for access to any component or software program shall be provided to the owner.

3.11 COMMISSIONING OF METER INSTALLATIONS

A. Each meter integrated to the EMIS shall be commissioned to verify functionality and accuracy of the parameters defined in this Standard. This includes but is not limited to:
   1. Verification of successful communications of the meters to the EMIS.
   2. Verification of required live point data at device and server levels.
   3. Verification of continuous historical trending at the device and server levels:
      a. Type of historical trend created in the database and required logic (delta vs accumulating)
      b. Increments of data storage
      c. Timestamp of data records
      d. Length of data storage at device and server levels
      e. Metrics and measured values for each meter application
   4. Point to point verification of collected data at the meter, device, and server levels (for water and electrical).
   5. Review of anticipated life cycle and recalibration time periods for installed meters.

3.12 MANUFACTURER'S FIELD SERVICES

A. Commissioning
   1. Commissioning the BAS is a mandatory documented performance requirement of the selected BAS Contractor for all control systems detailed in this Specification and sequence of operations. Documentation shall be presented upon completion of each

commissioning step and final completion to ensure proper operation of the BAS. Refer to the Commissioning Specification for more information.

B. LCS System Checkout and Testing
   1. System startup shall be provided by factory certified and trained employees of the LCS manufacturer. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration. Refer to 2.14 Laboratory Control System.

C. Noncompliant Items:
   1. The Contractor shall remove and replace, at their expense, all items that are not in compliance with the Specification requirements.

3.13 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
   1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
   2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
   3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
   4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
   5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
   6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
   7. Alarms and Interlocks:
   8. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   9. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   10. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.14 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration.
   1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
   2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
   3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.

4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "System Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:
    a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
    b. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
    c. Interface to the building fire alarm system.
10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.
1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.15 TRAINING

A. Provide professional video recording services to capture all training sessions. Reference Division 01 for requirements.

B. Provide 8 hours training for a designated staff of Owner's representatives. Training shall be classroom training and field training.
1. Field training shall provide operators and Owner's technical staff with facility specific details of the installation including the locations of field controllers, sequence of operations, network diagrams, etc.
2. 1Classroom training shall enable students to accomplish the following objectives.
3. Day-to-day Operators:
    a. Proficiently operate the system.
    b. Understand control system architecture and configuration.
    c. Understand BAS system components.
    d. Understand system operation, including BAS system control and optimizing routines (algorithms).
    e. Log on and off the system.
    f. Understand system drawings and Operation and Maintenance manual.

g. Understand the job layout and location of control components.
h. Access data from BAS controllers and ASCs

4. Advanced Operators:
   a. Make and change graphics on the workstation.
   b. Add, remove, and modify system's physical points.
   c. Create, modify, and delete programming.
   d. Add panels when required.
   e. Perform BAS system field checkout procedures.
   f. Perform BAS controller unit operation and maintenance procedures.
   g. Perform BAS system diagnostic procedures.
   h. Configure hardware including PC boards, switches, communication, and I/O points.
   i. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
   j. Adjust, calibrate, and replace system components.
5. System Managers/Administrators:
   a. Maintain software and prepare backups.
   b. Interface with job-specific, third-party operator software.
   c. Add new users and understand password security procedures.

C. Organize the training into sessions or modules for the three levels of operators listed above. (Day- to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on the knowledge level required.

D. Provide course outline and materials according to the submittal requirements of this specification. Provide one copy of training material per student.

E. The instructor(s) shall be factory-trained and experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers' representative of installed hardware.

G. Classroom training shall be held onsite. WTCC shall identify a classroom within the building where the training will be held.

H. Provide training for up to 8 people for day-to-day operators and advanced operators. Provide training for up to 4 people for system managers training.

END OF SECTION

SECTION 23 09 93 - SEQUENCE OF OPERATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes general requirements applicable to the control sequences for HVAC, Plumbing and Electrical systems, subsystems, and equipment.
   1. Refer to the Drawings for equipment and system sequence of operations.

1.02 DEFINITIONS

A. Analog Input (AI): Proportional input signal (zero- to 10-V dc, 4 to 20 mA).

B. Analog Output (AO): Proportional output signal (zero- to 10-V dc, 4 to 20 mA).

C. BACnet: Building Automation and Control Network

D. BAS: Building Automation System

E. Binary Input (BI): On/off input signal or contact closure.

F. Binary Output (BO): On/off output signal or contact closure.

G. DDC: Direct digital control.

H. Digital Output: Data output that must be interpreted digitally.

I. EMIS: Energy Management Information System

J. VFD: Variable Frequency Drive

1.03 ACTION SUBMITTALS

A. Product Data:
   1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
   2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

B. Shop Drawings:
   1. Riser diagrams showing control network layout, communication protocol, and wire types.
   2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
   3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.04 GENERAL

A. Refer to the Drawings for equipment and system sequence of operations.

B. The sequences describe the general intent of the control systems. Provide all devices, equipment, and wiring as required to perform the sequences described herein.

C. The sequences are intended to be performance based. Implementations that provide the same functional result using different underlying detailed logic will be acceptable.

D. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent windup.

E. When a control loop is enabled or reenabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a neutral value.

F. A control loop in neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.

G. EA-CEP shall provide ED-Tech 4.0 with Global OA-T & OA-H data to be used for all building systems. Sensor located in the AHU-3B OA intake shall be secondary to the global sensors.

1. The outdoor air temperature sensor at air-handler AHU-3B outdoor air intake shall be considered valid only when the supply fan is proven ON and the unit is in Occupied Mode or in any other mode with the economizer enabled.

H. The term “proven” (i.e., “proven on”/“proven off”) shall mean that the equipment's di status point (where provided, e.g., current switch, DP switch, or VFD status) matches the state set by the equipment's BO command point.

I. The term “software point” shall mean an analog variable, and “software switch” shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g., BACnet analog variable and binary variable).

J. The term “control loop” or “loop” is used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the guidelines in the following subsections shall be followed.

K. Use proportional only (P-only) loops for limiting loops (such as zone CO_2 control loops, etc.).

L. Do not use the derivative term on any loops unless field tuning is not possible without it.

M. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.

N. All setpoints, timers, deadbands, PID gains, etc. Listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

O. (Responsibility of Division 25 MSI – Included for Reference Only) Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g., for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point, and the software point shall be used in all sequences. Exceptions shall be made for machine or life safety.

1.05 ALARMS

A. There shall be 4 levels of alarm:
1. Level 1: Life-safety message
2. Level 2: Critical equipment message
3. Level 3: Urgent message
4. Level 4: Normal message

B. Maintenance Mode. Operators shall have the ability to put any device (e.g., AHU) in/out of maintenance mode.
1. All alarms associated with a device in maintenance mode will be suppressed. Exception: life safety alarms shall not be suppressed.
2. If a device is in maintenance mode, issue a daily Level 3 alarm at a scheduled time indicating that the device is still in maintenance mode.

C. Exit Hysteresis
1. Each alarm shall have an adjustable time-based hysteresis (default: 5 seconds) to exit the alarm. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.
2. Each analog alarm shall have an adjustable percent-of-limit-based hysteresis (default: 0% of the alarm threshold, i.e., no hysteresis; alarm exits at the same value as the alarm threshold) the alarmed variable required to exit the alarm. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis.

D. Latching. A latching alarm requires acknowledgment from the operators before it can return to normal, even if the exit deadband has been met. A nonlatching alarm does not require acknowledgment. Default latching status is as follows:

1. Level 1 alarms: latching
2. Level 2 alarms: latching
3. Level 3 alarms: nonlatching
4. Level 4 alarms: nonlatching

E. Post-Exit Suppression Period. To limit alarms, any alarm may have an adjustable suppression period such that once the alarm is exited, its post-exit suppression timer is triggered and the alarm may not trigger again until the post-exit suppression timer has expired. Default suppression periods are as follows:
1. Level 1 alarms: 0 minutes
2. Level 2 alarms: 5 minutes
3. Level 3 alarms: 24 hours
4. Level 4 alarms: 7 days

F. BAS and EMIS contractors shall obtain and review latest version of owner alarm guidelines and standards including owner's critical alarm list.

G. Contractor shall obtain alarm priorities from the WTCC project manager. These alarms will be synched to the EMIS using standard BACnet protocol when the field controller is connected to the network. Notifications of these alarms will be sent out via FIN front end.

H. Alarm extensions shall be created and prioritized according to WTCC BAS alarm standards. Operators with sufficient privilege shall be able to read and write alarm parameters for all standard BACnet alarm types. Operators with sufficient privilege shall be allowed to change routing (BACnet notification classes) for each alarm including the destination, time delay, priority class, day of week, time of day, and the type of transition involved.

I. Alarms shall be programmed with time delays and other logic to prevent nuisance tripping. Elimination of nuisance alarm notifications is a priority at WTCC.

J. (Responsibility of Division 25 MSI – Included for Reference Only) In order for alarm notifications to be sent to the correct email recipients, the designer and contractor shall use BACnet alarm levels shown in the BACnet alarm levels below. Coordinate each level of alarm with owner notification guidelines.
1. Level 1 alarms: BACnet Level 10
2. Level 2 alarms: BACnet Level 15
3. Level 3 alarms: BACnet Level 20
4. Level 4 alarms: BACnet Level 30

1.06 VFD SPEED POINTS

A. The speed AO signal sent to VFDs shall be configured such that 0% speed corresponds to 0 hz, and 100% speed corresponds to maximum speed configured in the VFD.

B. For each piece of equipment, the minimum speed shall be stored in a single software point; in the case of a hard-wired VFD interface, the minimum speed shall be the lowest speed command sent to the drive by the BAS. The active minimum speed parameter shall be read every 60 minutes via the drive's network interface. When a mismatch between the drive's active minimum speed and the minimum speed stored in the software point is detected, the minimum speed stored in the software point shall be written to the VFD via the network interface to restore the active minimum speed parameter to its default value and generate a Level 4 alarm.

C. VFDs operating in parallel shall receive the same speed signal.

1.07 TIME AND RESPOND (T&R) SET-POINT RESET LOGIC

A. T&R set-point reset logic and zone/system reset requests, where referenced in sequences, shall be implemented as described below.

B. A “request” is a call to reset a static pressure or temperature setpoint generated by downstream zones or air-handling systems. These requests are sent upstream to the plant or system that serves the zone or air handler that generated the request.
1. For each downstream zone or system, and for each type of set-point reset request listed for the zone/system, provide the following software points:

a. Importance-multiplier (default = 1)
b. Request-Hours Accumulator. Provided SystemOK (see Section 5.1.19) is TRUE for the zone/system, every x minutes (default 5 minutes), add x divided by 60 times the current number of requests to this request-hours accumulator point.
c. System Run-Hours Total. This is the number of hours the zone/system has been operating in any mode other than Unoccupied Mode.
d. Cumulative%-Request-Hours. This is the zone/system Request-Hours divided by the zone/system run-hours (the hours in any mode other than Unoccupied Mode) since the last reset, expressed as a percentage.
e. The Request-Hours Accumulator and System Run-Hours Total are reset to zero as follows:
    1) Reset automatically for an individual zone/system when the System Run-Hours Total exceeds 400 hours.
    2) Reset manually by a global operator command. This command will simultaneously reset the Request-Hours point for all zones served by the system.
f. A Level 4 alarm is generated if the zone Importance-Multiplier is greater than zero, the zone/system Cumulative% Request Hours exceeds 70%, and the total number of zone/system run hours exceeds 40.

2. See zone and air-handling system control sequences for logic to generate requests.
3. Multiply the number of requests determined from zone/system logic times the Importance-Multiplier and send to the system/plant that serves the zone/system. See system/plant logic to see how requests are used in T&R logic.

C. For each upstream system or plant setpoint being controlled by a T&R loop, define the following variables. Initial values are defined in system/plant sequences below. Values for trim, respond, time step, etc. shall be tuned to provide stable control.

D. Standard Trim & Respond Variable Definitions:
1. Device = Associated device (ex fan, pump)
2. SP_0 = Initial setpoint
3. SP_MIN = Minimum setpoint
4. SP_MAX = Maximum setpoint
5. T_D = Delay timer
6. T = Time step
7. I = Number of ignored requests
8. R = Number of requests from zones/systems
9. SP_TRIM = Trim amount
10. SP_RES = Respond amount (must be opposite in sign to SP_TRIM)
11. SP_RES-MAX = Maximum response per time interval (must be same sign as SP_RES)

E. Trim & Respond logic shall reset the setpoint within the range SPmin to SPmax. When the associated device is OFF, the setpoint shall be SP0. The reset logic shall be active while the associated device is proven ON, starting Td after initial device start command. When active, every time step T, if R≤I, trim the setpoint by SPtrim. If there are more than I requests, respond by changing the setpoint by SPres*(R – I), (i.e., the number of requests minus the number of ignored requests) but no more than SPres-max. In other words, every time step T.
1. if R≤I, change Setpoint by SPtrim
2. If R > I, change setpoint by (R – I)*SPres but no larger than SPres-max

F. Example Sequence T&R Variables:
1. DEVICE = Supply Fan
2. SP0 = 0.5 in. of water
3. SPmin = 0.15 in. of water
4. SPmax = 1.50 in. of water
5. Td = 5 minutes
6. T = 2 minutes
7. I = 2 requests

8. SPtrim = -0.04 in. of water
9. SPres = +0.06 in. of water
10. SPres-max = +0.15 in. of water

1.08 EQUIPMENT STAGING AND ROTATION

A. Parallel equipment shall be lead/lag or lead/standby rotated to maintain even wear.

B. Two runtime points shall be defined for each equipment:
   1. Lifetime Runtime: The cumulative runtime of the equipment since equipment start-up. This point shall not be readily resettable by operators.
   2. Staging Runtime: An operator resettable runtime point that stores cumulative runtime since the last operator reset.

C. Lead/lag equipment: Unless otherwise noted, identical parallel staged equipment (such as CHW pumps and cooling towers) shall be lead/lag alternated when more than one is off or more than one is on so that the equipment with the most operating hours as determined by Staging Runtime is made the last stage equipment and the one with the least number of hours is made the lead stage equipment.

D. Lead/standby equipment:
   1. Unless equipment runs continuously, parallel equipment that are 100% redundant shall be lead/standby alternated when more than one of the equipment is off so that the equipment with the most operating hours as determined by Staging Runtime is made the last stage equipment and the one with the least number of hours is made the earlier stage equipment.
   2. If equipment runs continuously, lead/standby positions shall switch at an adjustable day of the week and time (e.g., every Tuesday at 10:00 am) based on Staging Runtime; standby equipment shall first be started and proven on before former lead equipment is changed to standby and shut off.
      a. Variable speed fans and pumps shall have a deceleration rate of 1 Hz/second or slower set in BAS logic when disabled to prevent nuisance trips of operating equipment.

E. Exceptions to Lead/lag and Lead/Standby rotation
   1. Operators with appropriate access level shall be able to manually command staging order via software points, but not overriding the In-Alarm or Hand-Operation logic in the following subsections.
      a. Staging order changes initiated via operator override shall be instituted as part of normal staging events.
      b. Staging order shall remain overridden until released by operators.
   2. Faulted Equipment:
      a. A faulted equipment is any equipment commanded to run that is either not running or unable to perform its required duty. If an operating equipment has any fault condition described subsequently, a Level 2 alarm shall be generated and a response shall be triggered as defined below.
         1) Fans and Pumps
            a) Status point not matching its on/off point for 3 seconds after a time delay of 15 seconds while the equipment is commanded on.

1.09 AIR ECONOMIZER HIGH LIMITS

A. Refer to Drawings for economizer sequence of operations.

1.10 DAMPER / VALVE POSITION

A. Knowledge of damper and valve position are required for proper generation of T&R reset requests.

B. The following are acceptable methods for determining position:
   1. Analog actuator. Position may be assumed to be equal to analog signal to actuator.
   2. Floating actuator. Position feedback AI.

1.11 HIERARCHICAL ALARM SUPPRESSION (DIVISION 25 MSI SCOPE – INCLUDED FOR REFERENCE ONLY)

A. For each piece of equipment or space controlled by the BAS, define its relationship (if any) to other equipment in terms of “source,” “load,” or “system.”
   1. A component is a “source” if it provides resources to a downstream component, such as a chiller providing chilled water (CHW) to an AHU.
   2. A component is a “load” if it receives resources from an upstream component, such as an AHU that receives CHW from a chiller.
   3. The same component may be both a load (receiving resources from an upstream source) and a source (providing resources to a downstream load).
   4. A set of components is a “system” if they share a load in common (i.e., collectively act as a source to downstream equipment, such as a set of chillers in a lead/lag relationship serving air handlers).
      a. If a single component acts as a source for downstream loads (e.g., an AHU as a source for its vav boxes), then that single-source component shall be defined as a “system” of one element.
      b. For equipment with associated pumps (chillers, boilers, cooling towers):
         1) If the pumps are in a one-to-one relationship with equipment they serve, the pumps shall be treated as part of the system to which they are associated (i.e., they are not considered loads), as a pump failure will necessarily disable its associated equipment.
         2) If the pumps are headered to the equipment they serve, then the pumps may be treated as a system, which is a load relative to the upstream equipment (e.g., chillers) and a source relative to downstream equipment (e.g., air handlers).

B. For each system, there shall be a SystemOK flag, which is either TRUE or FALSE.

C. SystemOK shall be TRUE when all of the following are true:
   1. The system is proven on.
   2. The system is achieving its temperature and/or pressure setpoint(s) for at least 5 minutes.
   3. The system is ready and able to serve its load.

D. SystemOK shall be FALSE while the system is starting up (i.e., before reaching setpoint) or when enough of the system's components are unavailable (in alarm, disabled, or turned off) to disrupt the ability of the system to serve its load. This threshold shall be defined by the design engineer for each system.
   1. By default, Level 1 through Level 3 component alarms (indicating equipment failure) shall inhibit SystemOK. Level 4 component alarms (maintenance and energy efficiency alarms) shall not affect SystemOK.
   2. The operator shall have the ability to individually determine which component alarms may or may not inhibit SystemOK.

E. The BAS shall selectively suppress (i.e., fail to announce; alarms may still be logged to a database) alarms for load components if SystemOK is false for the source system that serves that load.
   1. If SystemOK is FALSE for a cooling water system (i.e., chiller, cooling tower, or associated pump), then only high-temperature alarms from the loads shall be suppressed.
   2. If SystemOK is FALSE for a heating water system (i.e., boiler or associated pump), then only low temperature alarms from the loads shall be suppressed.
   3. If SystemOK is FALSE for an air-side system (air handler, fan coil, vav box, etc.), then all alarms from the loads shall be suppressed.

F. This hierarchical suppression shall cascade through multiple levels of load-source relationship such that alarms at downstream loads shall also be suppressed.

G. The following types of alarms will never be suppressed by this logic:
   1. Life/safety and Level 1 alarms
   2. Failure-to-start alarms (i.e., equipment is commanded on, but status point shows equipment to be off)

3. Failure-to-stop/hand alarms (i.e., equipment is commanded off, but status point shows equipment to be on)

1.12 TIME BASED SUPPRESSION

A. Calculate a time-delay period after any change in setpoint based on the difference between the controlled variable (e.g., zone temperature) at the time of the change and the new setpoint. The default time delay period shall be as follows:
   1. For thermal zone temperature alarms: 10 minutes per °F of difference but no longer than 120 minutes.
   2. For thermal zone temperature cooling requests: 5 minutes per °F of difference but no longer than 30 minutes.
   3. For thermal zone temperature heating requests: 5 minutes per °F of difference but no longer than 30 minutes.

1.13 GENERIC THERMAL ZONES

A. This section applies to all single-zone systems and subzones of air-handling sytems, such as VAV boxes, fan-powered boxes, etc.

B. Setpoints:
   1. Occupied temperature setpoints for each space type shall be per WTCC Guidelines. Prior to programming controllers, the BAS Controls contractor shall meet with WTCC where setpoints for each space type will be confirmed.
   2. Each zone shall have separate occupied and unoccupied heating and cooling setpoints.
   3. The active setpoints shall be determined by the operating mode of the Zone Group.
      a. The set points shall be the occupied set points during Occupied Mode, Standby Mode, Warm-up Mode, and Cooldown Mode.
      b. The set points shall be the unoccupied set points during Unoccupied Mode, Setback Mode, and Setup Mode.
   4. All zone temperature setpoint logic (Occupied, Unoccupied, Standby, Setback, Setup, Warmup, Cooldown) must write to an effective zone temperature setpoint (effstpt) for WTCC front end floor plan graphic coloring to work, i.e. zone below effstpt = zone is blue, zone above effstpt = zone is red).
   5. The software shall prevent the following:
      a. The heating setpoint from exceeding the cooling setpoint minus 3°F (i.e., the minimum difference between heating and cooling setpoints shall be 1°F).
      b. The unoccupied heating setpoint from exceeding the occupied heating setpoint.
      c. The unoccupied cooling setpoint from being less than the occupied cooling setpoint.
   6. Where the zone has a local setpoint adjustment knob/button:
      a. The setpoint adjustment offsets established by the occupant shall be software points that are persistent (e.g., not reset daily), but the actual offset used in control logic shall be adjusted based on limits and modes as described below.
      b. The adjustment shall be capable of being limited in software.
         1) As a default, the active user adjustment/variation shall be 1°F from setpoint.
      c. Setpoints for all other modes of operation shall not be impacted by the local setpoint adjustment device.
         1) The active heating and cooling setpoints shall be independently adjustable, respecting the limits and anti-overlap logic. If zone thermostat provides only a single set-point adjustment, then the adjustment shall move both the active heating and cooling setpoints upward or downward by the same amount, within the limits.
         2) The adjustment shall only affect occupied setpoints in Occupied Mode, Warmup Mode, and Cooldown Mode and shall have no impact on setpoints in all other modes.
         3) At the onset of demand limiting, the local set-point adjustment value shall be frozen. Further adjustment of the setpoint by local controls shall be suspended for the duration of the demand-limit event.
   7. Demand Limiting

a. Cooling demand limit set-point adjustment. The active cooling setpoints for all zones shall be increased when a demand limit is imposed on the associated zone group. The operator shall have the ability to exempt individual zones from this adjustment through the normal BAS user interface. Changes due to demand limits are not cumulative.
   1) At demand-limit Level 1, increase setpoint by 1°F.
   2) At demand-limit Level 2, increase setpoint by 2°F.
   3) At demand-limit Level 3, increase setpoint by 4°F.

b. Heating demand-limit set-point adjustment. The active heating setpoints for all zones shall be decreased when a demand limit is imposed on the associated zone group. The operator shall have the ability to exempt individual zones from this adjustment through the normal BAS user interface. Changes due to demand limits are not cumulative.
   1) At demand-limit Level 1, decrease setpoint by 1°F.
   2) At demand-limit Level 2, decrease setpoint by 2°F.
   3) At demand-limit Level 3, decrease setpoint by 4°F.

c. Occupancy sensors. For zones that have an occupancy switch:
   1) When the switch indicates that the space has been unpopulated for 15 minutes (adj.) continuously during the occupied mode, the active heating setpoint shall be decreased and the cooling setpoint shall be increased to the WTCC standby setpoints. Setpoints shall be specific to the individual zone program and per the WTCC provided “Space Temperatures Standard”.
   2) When the switch indicates that the space has been populated for 1 minute continuously, the active heating and cooling setpoints shall be restored to their previous values.

d. Hierarchy of set-point adjustments. The following adjustment restrictions shall prevail in order from highest to lowest priority:
   1) Setpoint overlap restriction
   2) Absolute limits on local setpoint adjustment
   3) Demand limit
      a) Occupancy sensors. Change of setpoint by occupancy sensor is added to change of setpoint by any demand limits in effect.
      b) Local set-point adjustment. Any changes to setpoint by local adjustment are frozen at the onset of the demand limiting event and remain fixed for the duration of the event. Additional local adjustments are ignored for the duration of the demand limiting event.
   4) Scheduled setpoints based on zone group mode.

C. Local Override. When thermostat override buttons are depressed, the call for Occupied Mode operation shall be sent to the Zone Group control for 60 minutes.

D. Control Loops
1. Two separate control loops, the cooling loop and the heating loop, shall operate to maintain space temperature at setpoint.
   a. The heating loop shall be enabled whenever the space temperature is below the current zone heating set-point temperature and disabled when space temperature is above the current zone heating setpoint temperature and the loop output is zero for 30 seconds. The loop may remain active at all times if provisions are made to minimize integral windup.
   b. The cooling loop shall be enabled whenever the space temperature is above the current zone cooling set-point temperature and disabled when space temperature is below the current zone cooling set-point temperature and the loop output is zero for 30 seconds. The loop may remain active at all times if provisions are made to minimize integral windup.
2. The cooling loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a software point ranging from 0% (no cooling) to 100% (full cooling).

3. The heating loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a software point ranging from 0% (no heating) to 100% (full heating).
4. Loops shall use P&I logic or other technology with similar performance. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P&I gains shall be adjustable by the operator.
5. See other sections for how the outputs from these loops are used.

E. Zone Groups
1. Each system shall be broken into separate Zone Groups composed of a collection of one or more zones served by a single air handler.
   a. Typically WTCC schedules equipment (AHU's) per floor, i.e. terminal units served by AHU will have same occupancy times.
2. Each Zone Group shall be capable of having separate occupancy schedules and operating modes from other Zone Groups.
3. All zones in each Zone Group shall be in the same Zone-Group Operating Mode. If one zone in a Zone Group is placed in any zone-group operating mode other than Unoccupied Mode (due to override, sequence logic, or scheduled occupancy), all zones in that Zone Group shall enter that mode.
4. A Zone Group may be in only one mode at a given time.
5. For each Zone Group, provide a set of testing/commissioning software switches that override all zones served by the Zone Group. Provide a separate software switch for each of the zone-level override switches listed under “Testing and Commissioning Overrides” in terminal unit sequences. When the value of a Zone Group’s override switch is changed, the corresponding override switch for every zone in the Zone Group shall change to the same value. Subsequently, the zone-level override switch may be changed to a different value. The value of the zone-level switch has no effect on the value of the zone-group switch, and the value of the zone-group switch only affects the zone-level switches when the zone-group switch is changed.
6. Zone-Group Operating Modes. Each Zone Group shall have the modes shown in the following subsections.
   a. Occupied Mode. A Zone Group is in the Occupied Mode when any of the following is true:
      1) The time of day is between the Zone Group’s scheduled occupied start and stop times.
      2) The schedules have been overridden by the occupant override system.
      3) Any zone local override timer (initiated by local override button) is nonzero.
   b. Warmup Mode. For each zone, the BAS shall calculate the required warmup time based on the zone’s occupied heating setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. Zones where the window switch indicates that a window is open shall be ignored. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned on or off by a software switch to allow tuning to be stopped after the system has been trained. Warmup Mode shall start based on the zone with the longest calculated warmup time requirement, but no earlier than 3 hours before the start of the scheduled occupied period, and shall end at the scheduled occupied start hour.
   c. Cooldown Mode. For each zone, the BAS shall calculate the required cooldown time based on the zone’s occupied cooling setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. Zones where the window switch indicates that a window is open shall be ignored. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned on or off by a software switch to allow tuning to be stopped after the system has been trained. Cooldown Mode shall start based on the zone with the longest calculated cooldown time requirement, but no earlier than 3 hours before the

start of the scheduled occupied period, and shall end at the scheduled occupied start hour.

d. Setback Mode.
   1) Temperature: During Unoccupied Mode, if any 5 zones (or all zones if fewer than 5) in the Zone Group fall below their unoccupied heating temperature setpoints, or if the average zone temperature of the Zone Group falls below the average unoccupied heating setpoint, the Zone Group shall enter Setback Mode until all spaces in the Zone Group are 2°F above their unoccupied setpoints.
   2) Relative Humidity (where applicable): During Unoccupied Mode, if any 5 zones (or all zones if fewer than 5) in the Zone Group fall below their unoccupied heating relative humidity setpoints, or if the average zone relative humidity of the Zone Group falls below the average unoccupied heating setpoint, the Zone Group shall enter Setback Mode until all spaces in the Zone Group are 5%RH above their unoccupied setpoints.

e. Freeze Protection Setback Mode. During Unoccupied Mode, if any single zone falls below 40°F, the Zone Group shall enter Setback Mode until all zones are above 45°F, and a Level 3 alarm shall be set.

f. Setup Mode.
   1) Temperature: During Unoccupied Mode, if any 5 zones (or all zones if fewer than 5) in the Zone Group rise above their unoccupied cooling temperature setpoints, or if the average zone temperature of the Zone Group rises above the average unoccupied cooling setpoint, the Zone Group shall enter Setup Mode until all spaces in the Zone Group are 2°F below their unoccupied setpoints. Zones where the window switch indicates that a window is open shall be ignored.
   2) Relative Humidity: During Unoccupied Mode, if any 5 zones (or all zones if fewer than 5) in the Zone Group rise above their unoccupied cooling relative humidity setpoints, or if the average zone relative humidity of the Zone Group rises above the average unoccupied cooling relative humidity setpoint, the Zone Group shall enter Setup Mode until all spaces in the Zone Group are 5%RH below their unoccupied setpoints.

g. Unoccupied Mode. When the Zone Group is not in any other Mode.

F. Zone Alarms
   1. Zone Temperature Alarms
      a. High-temperature alarm
         1) If the zone is 3°F above cooling setpoint for 10 minutes, generate a Level 4 alarm.
         2) If the zone is 5°F above cooling setpoint for 10 minutes, generate a Level 3 alarm.
      b. Low-temperature alarm
         1) If the zone is 3°F below heating setpoint for 10 minutes, generate a Level 4 alarm.
         2) If the zone is 5°F below heating setpoint for 10 minutes, generate a Level 3 alarm.
      c. Suppress zone temperature alarms as follows:
         1) After zone setpoint is changed.
         2) While Zone Group is in Warmup Mode or Cooldown Mode.

1.14 DIFFERENTIAL PRESSURE TRANSMITTER

A. A differential pressure transmitter (DPT) shall be installed on the campus HHW and CHW distribution loop side within the building and upstream of the bridges and shall be used for pump speed control at the CEP.

1.15 REFERENCES TO OUTDOOR AIR CONDIITONS

A. Unless otherwise specified in specific sequences, all references to outdoor air conditions shall use data from a centralized WTCC east campus weather station for outdoor air conditions installed at the east campus Central Energy Plant (CEP).

B. Outdoor air data from the reference weather station shall be integrated from the CEP through the WTCC EMIS to the building automation system installed in this building.

C. If the CEP weather station sensors fail, or if the integration of weather data passed to the BAS from the EMIS fails, the BAS shall:
   1. Use the AHU-3B outdoor air temperature, relative humidity and carbon dioxide sensors.
   2. Generate and communicate a Level 2 alarm.
   3. If the failure persists for 24-hours (adj.) generate and communicate a Level 3 alarm.

1.16 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION (Not Applicable)

END OF SECTION

SECTION 23 11 23 - FACILITY NATURAL-GAS PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Natural gas piping buried within 5 feet of building.
   2. Natural gas piping above grade.
   3. Unions and flanges.
   4. Valves.
   5. Strainers.
   6. Natural gas pressure regulators.
   7. Natural gas pressure relief valves.
   8. Underground pipe markers.

1.02 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, provide compatible system components and joints. Use non-conducting dielectric connections when joining dissimilar metals in systems.

B. Provide flanges, unions, or couplings at locations requiring servicing. Use unions, flanges, or couplings downstream of valves and at equipment connections. Do not use direct welded or threaded connections to valves, equipment.

C. Provide pipe hangers and supports in accordance with ASME B31.9.

1.03 SUBMITTALS

A. Product Data:
   1. Piping: Submit data on pipe materials, fittings, and accessories. Submit manufacturers catalog information.
   2. Valves: Submit manufacturers catalog information with valve data and ratings for each service.
   3. Hangers and Supports: Submit manufacturers catalog information including load capacity.
   4. Piping Specialties: Submit manufacturers catalog information including capacity, rough-in requirements, and service sizes for the following:
      a. Strainers.
      b. Natural gas pressure regulators.
      c. Natural gas pressure relief valves.

B. Design Data: Indicate pipe size. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.

C. Test Reports: Indicate results of piping system pressure test.

D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

E. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.

1.04 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of valves, piping system, and system components.

B. Operation and Maintenance Data: Valves and gas pressure regulators installation instructions, spare parts lists, and exploded assembly views.

1.05 QUALITY ASSURANCE

A. Perform natural gas Work in accordance with NFPA 54.

B. Perform Work in accordance with ASME B31.9 code for installation of piping systems and ASME Section IX for welding materials and procedures.

C. Furnish shutoff valves complying with ASME B16.33 or ANSI Z21.15.

D. Maintain one copy of each document on site.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Protect piping and fittings from soil and debris with temporary end caps and closures. Maintain in place until installation. Furnish temporary protective coating on cast iron and steel valves.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.08 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.09 MAINTENANCE MATERIALS

A. Furnish two packing kits for each type and size valve.

PART 2 PRODUCTS

2.01 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
   1. Fittings: ASTM A234/A234M forged steel welding type.
   2. Joints: ASME B31.9, welded.
   3. Jacket: AWWA C105 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2.02 NATURAL GAS PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
   1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M forged steel welding type.
   2. Joints: Threaded for pipe 2 inch and smaller; welded for pipe 2-1/2 inches and larger.

B. Copper Tubing: ASTM B88, Type K annealed.
   1. Fittings: ASME B16.26 cast bronze, compression type.
   2. Joints: Flared.

2.03 UNIONS AND FLANGES

A. Unions for Pipe 2 inches and Smaller:
   1. Ferrous Piping: Class 150, malleable iron, threaded.
   2. Copper Piping: Class 150, bronze unions with soldered or brazed joints.
   3. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

B. Flanges for Pipe 2-1/2 inches and Larger:
   1. Ferrous Piping: Class 150, forged steel, slip-on flanges.
   2. Copper Piping: Class 150, slip-on bronze flanges.
   3. Gaskets: 1/16 inch thick preformed neoprene gaskets.

2.04 BALL VALVES

A. Manufacturers:
   1. Crane Valve.
   2. Hammond Valve.
   3. Milwaukee Valve Company.
   4. NIBCO, Inc.

5. Stockham Valves & Fittings.

B. 1/4 inch to 1 inch: MSS SP 110, Class 125, two piece, threaded ends, bronze body, chrome plated bronze ball, reinforced teflon seats, blow-out proof stem, lever handle, UL 842 listed for flammable liquids and LPG, full port.

2.05 PLUG VALVES

A. Manufacturers:
1. DeZURIK, Unit of SPX Corp.
2. Flow Control Equipment, Inc.
3. Homestead Valve.

B. 2 inches and Smaller: MSS SP 78, Class 150, semi-steel construction, full pipe area, pressure lubricated, teflon packing, threaded ends. Furnish one plug valve wrench for every ten plug-valves with minimum of one wrench.

C. 2-1/2 inches and Larger: MSS SP 78, Class 150, semi-steel construction, full pipe area, pressure lubricated, teflon packing, flanged ends. Furnish wrench-operated.

2.06 BUTTERFLY VALVES

A. Manufacturers:
1. Crane Valve, North America.
2. Hammond Valve.
3. Milwaukee Valve Company.
4. NIBCO, Inc.
5. Stockham Valves & Fittings.

B. 2 inches and Smaller: MSS SP 67, 175 psi, bronze body, Viton seals, stainless steel trim, lever handle UL 842 listed for gas service, threaded ends, full port.

2.07 STRAINERS

A. Manufacturers:
1. Mueller Steam Specialty.
2. O.C. Keckley Company.
3. Spirax Sarco, Inc.

B. 2 inch and Smaller: Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

C. 2-1/2 inch to 4 inch: Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

D. 5 inch and Larger: Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.08 NATURAL GAS PRESSURE REGULATORS

A. Product Description: Spring loaded, general purpose, self-operating service regulator including internal relief type diaphragm assembly and vent valve. Diaphragm case can be rotated 360 degrees in relation to body.
1. Temperatures: minus 20 degrees F to 150 degrees F.
2. Body: Cast iron.
3. Spring case, lower diaphragm casing, union ring, seat ring and disk holder: Aluminum.
4. Disk, diaphragm, and O-ring: Nitrile.
5. Maximum inlet pressure: 150 psig.
6. Furnish sizes 2 inches and smaller with threaded ends. Furnish sizes 2-1/2 inches and larger with flanged ends.

2.09 NATURAL GAS PRESSURE RELIEF VALVES

A. Product Description: Spring loaded type relief valve.

1. Body: Aluminum.
2. Diaphragm: Nitrile.
3. Orifice: Brass.
4. Maximum operating temperature: 150 degrees F.
5. Inlet Connections: Threaded.
6. Outlet or Vent Connection: Same size as inlet connection.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION - BURIED PIPING SYSTEMS

A. Install natural gas piping in accordance with NFPA 54.

B. Verify connection to existing piping system size, location, and invert are as indicated on Drawings.

C. Establish elevations of buried piping with not less than 3 ft of cover.

D. Establish minimum separation from other services in accordance with North Carolina Building code.

E. Remove scale and dirt on inside of piping before assembly.

F. Install pipe to elevation as indicated on Drawings.

G. Place bedding material at trench bottom to provide uniform bedding for piping, level bedding materials in one continuous layer not exceeding 4 inches compacted depth; compact to 95 percent maximum density.

H. Install pipe on prepared bedding.

I. Route pipe in straight line.

J. Install pipe to allow for expansion and contraction without stressing pipe or joints.

K. Install plastic ribbon tape continuous buried 6 inches below finish grade, above pipe line.

L. Pipe Cover and Backfilling:
   1. Maintain optimum moisture content of fill material to attain required compaction density.
   2. After hydrostatic test, evenly backfill entire trench width by hand placing backfill material and hand tamping in 6 inches compacted layers to 12 inches minimum cover over top of jacket. Compact to 95 percent maximum density.
   3. Evenly and continuously backfill remaining trench depth in uniform layers with backfill material.
   4. Do not use wheeled or tracked vehicles for tamping.

3.04 INSTALLATION - ABOVE GROUND PIPING SYSTEMS

A. Install natural gas piping in accordance with NFPA 54.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Sleeve pipe passing through partitions, walls and floors.

H. Install firestopping at fire rated construction perimeters and openings containing penetrating sleeves and piping.

I. Provide clearance for installation of insulation and access to valves and fittings.

J. Provide access where valves and fittings are not exposed.

K. Where pipe support members are welded to structural building framing, scrape, brush clean, weld, and apply one coat of zinc rich primer.

L. Provide support for utility meters in accordance with requirements of utility company.

M. Install vent piping from gas pressure reducing valves to outdoors and terminate in weatherproof hood.

N. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting.

O. Install identification on piping systems including underground piping.

P. Install valves with stems upright or horizontal, not inverted.

Q. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

R. Install medium pressure gas pressure regulator with tee fitting between regulator and upstream shutoff valve. Cap or plug one opening of tee fitting.

S. Install medium pressure gas pressure regulator with tee fitting not less than 10 pipe diameters down stream of regulator. Cap or plug one opening of tee fitting.

T. Install gas pressure regulator with independent vent full size opening on regulator and terminate outdoors as indicated on Drawings.

U. Gas service distribution piping to have initial minimum pressure of 5 psi.

3.05 FIELD QUALITY CONTROL

A. Field inspecting, testing, adjusting, and balancing. Pressure test natural gas piping in accordance with NFPA 54.

B. When pressure tests do not meet specified requirements, remove defective work, replace and retest.

END OF SECTION

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Glycol heating water piping
   4. Condensate-drain piping.
   5. Air-vent piping.
   6. Safety-valve-inlet and -outlet piping.

1.02 ACTION SUBMITTALS

A. Product Data for Sustainability Reporting: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.04 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
   2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.05 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at 200 deg F.
3. Glycol heating water piping: 150 psig at 200 deg F.
4. Condensate-Drain Piping: 150 deg F.
5. Air-Vent Piping: 200 deg F.

2.02 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L and ASTM B 88, Type M.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. Wrought-Copper Unions: ASME B16.22.

2.03 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

2.04 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.05 DIELECTRIC FITTINGS

A. General Requirements: Wake Tech does not use dielectric fittings to separate the assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Instead, provide brass shut-off valves in their place.

PART 3 EXECUTION

3.01 PIPING APPLICATIONS

A. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Hot-water heating piping, aboveground, NPS 2-1/2and larger shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Glycol heating water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

F. Glycol heating water piping, aboveground, NPS 2-1/2and larger shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

G. Makeup-water piping installed aboveground shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

H. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

I. Air-Vent Piping:
   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
   2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

3.02 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 23 05 23 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.03 DIELECTRIC FITTING INSTALLATION

A. Install brass shut off valves instead of dielectric fittings in piping at connections of dissimilar metal piping and tubing.

3.04 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 7 feet.
   2. NPS 1: Maximum span, 7 feet.
   3. NPS 1-1/2: Maximum span, 9 feet.
   4. NPS 2: Maximum span, 10 feet.
   5. NPS 2-1/2: Maximum span, 11 feet.
   6. NPS 3 and Larger: Maximum span, 12 feet.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.05 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.06 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 05 19 "Gages for HVAC Piping."

3.07 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
   4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 23 21 14 – UNDERGROUND HYDRONIC PIPING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This specification covers the requirements for furnishing all labor, materials, equipment, and incidentals required to install High Density Polyethylene (HDPE) pressure pipe, fittings, and appurtenances per the Contract Documents for underground hot water and chilled water piping.

B. All underground low-temperature hot water lines shall be a complete HDPE jacketed system of factory pre-insulated piping. The system supplier shall have fabricated systems of the composition herein for at least ten years. All straight sections, fittings, anchors, and other accessories shall be factory prefabricated to job dimensions and designed to minimize the number of field joints. The preapproved conduit system shall include all piping and components to a point twelve inches inside the building, or manhole wall.

1.02 REFERENCED STANDARDS

A. All standard specifications, i.e., Federal, ANSI, ASTM, ASME etc., made a portion of these Specifications by reference, shall be the latest edition and revision thereof.

1.03 QUALIFICATIONS

A. Manufacturers that are qualified and approved are listed in Section 2.1 G. Products from manufacturers not listed are prohibited unless approved by A/E.

B. The Pipe and Resin manufacturers shall have at least 7 years of experience producing a similar size pipe and similar resin types.

C. The Pipe Manufacturer shall provide support for the Industry through active membership and participation in Plastic Pipe Institute (PPI), American Water Works Association (AWWA), American Society of Testing and Materials (ASTM), American Gas Association (AGA), American Society of Civil Engineers (ASCE), and American Society of Mechanical Engineers, (ASME).

D. Laborer(s) who are installing and/or fusing HDPE pipe shall have a minimum of five years' experience performing this type of work. The Pipe Distributor supplying the HDPE pipe must offer fusion training to the contractor. The Pipe Distributor should also submit proof they are qualified to offer such training. Persons making heat fusion joints must have received training for butt fusion and electro-fusion in the Manufacturer's recommended procedure. Certify that training was received not more than 12 months before commencing construction.

E. Contractor that is electrofusing HDPE pipe shall have a manufacturer or distributor representative of the electrofusion coupling provider on site during all electrofusion operations.

1.04 SUBMITTALS

A. Submit to the A/E, a list of materials to be furnished, the names of the suppliers, and the appropriate shop drawings for all HDPE pipe and fittings, as required in Division 1. Datalog records for all factory fusion welding of HDPE pipe and fittings shall be submitted to the A/E for review and approval prior to on-site installation of pipe material.

B. Submit the pipe manufacturer's certification of compliance and MSDS sheets with the applicable sections of the Specifications.

C. Submit shop drawings showing installation method and the proposed method and specialized equipment to be used, including but not limited to manufacturer's recommended fusing procedures for the products.

D. Contractor shall submit qualifications and resume for all laborers performing installation, fusing, and supervising of HDPE pipe. This includes, but is not limited to written, verifiable proof that

the Contractor is certified by the fusion systems manufacturer(s) as a fully-trained user. Contractor must comply with qualifications as stated above.

E. Contractor shall submit fusion map showing placement of all proposed electrofusion and butt fusion joints. Joints shall be numbered individually.

F. Product data for valves, pipe appurtenances and identification devices. For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

G. Shop Drawings: For underground low-temperature heating water piping. Signed and sealed by a professional engineer licensed in the state where the project is located.

1. System Layout: Piping layout with part IDs indicating pipe sizes, dimensions, and elevations at same scale as Contract Drawings. Layout shall indicate location of all fabricated specialties including anchors, end caps, field joints, vertical bends, and horizontal bends as required by the contract drawings and the stress analysis. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations Layout shall include nomenclature and labels corresponding to the stress analysis for comparing layout to the analysis. Any changes to the pipe alignment, anchor locations, or end terminations from the design documents must be approved by the Designer and shall be identified in the submittal.
2. System Details: Details of fabrication, materials and method of support for all fabricated specialties. Details to be provided at a minimum include bolster pad installation and schedule, anchor details, penetration details, end caps, trench sections with bedding requirements, pipe connection, field joints, valve component and insulation details, branch details, etc. The Contractor shall obtain written certification from underground distribution piping system manufacturer verifying that the conduit system contains no voids in the insulation prior to shipment to the job site. All insulation shall be factory tested for voids prior to application of the protective jacket by infrared inspection over the entire length or x-ray over the entire length.
3. Stress Analysis: A complete engineering stress analysis indicating all anchors, fittings, dimensions in three axes, maximum anticipated stresses and maximum allowable stresses, and maximum deflections. A revised stress analysis must be completed and provided for review prior to making any field changes to the system. Stress analysis must be sealed by a licensed professional engineer in the state of the project location. Manufacturer is to design anchors based on stress analysis and provide calculations, details of fabrication, installation requirements, and dimensions. Calculations and details are to be signed by a license professional engineer in the state of the project.

H. Hydrostatic Test Plan: Contractor is to submit a written plan and drawings for the hydrostatic test. The plan is to include all procedures and shutdowns necessary for the hydrostatic test. Plans are to identify temporary and permanent fill points, vents, bypasses, valves, gauges, and other appurtenances needed.

I. Record Documents: Show dimensioned locations of underground utilities and manholes. Contractor shall engage a licensed surveyor to survey the installed utilities and manholes to record horizontal and vertical elevations at all horizontal and vertical alignment changes. Survey points are to be submitted in AutoCAD format and tied to project datum. Contractor shall submit AutoCAD file along with record drawings to Designer. All existing utility crossings encountered shall be surveyed and shown on the as-built drawing with size and type of utility notated. Survey shall be obtained prior to backfilling piping.

1.05 INSPECTIONS AND TESTS

A. All work shall be inspected by the Owner’s representative who shall have the authority to halt construction if these specifications or standard construction practices are not being followed.

Whenever any portion of these specifications is violated, the Owner and/or A/E may order further construction to cease until all deficiencies are corrected.

1.6 DELIVERY, STORAGE AND HANDLING

A. Provide factory-applied plastic end-caps on each length of pipe. Maintain end-caps through shopping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris and moisture.

B. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. Piping and pipe ends may not rest of the ground and must be neatly stored per manufacturer's instructions. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fitting and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

D. Contractor is responsible for transporting pipe from the location pipe is being stored to the project site.

E. Ensure valves are dry and internally protected against rust and corrosion. Set valves in best position for handling & set valve closed. Do not remove end protectors unless necessary for inspection; then reinstall for storage. Keep valves protected from weather by storing indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement.

F. Use a sling to handle valves whose size requires handling by crane or lift. Rig all valves in a manner that avoids damage to exposed valve parts. Do not use hand wheels or stems as lifting or rigging points.

1.06 WARRANTY AND ACCEPTANCE

A. Warrant all work to be free from defects in workmanship and materials for a period of one year from the date of completion of all construction. If work meets these specifications, a letter of acceptance, subject to the one year warranty period, shall be given at the time of completion. A final acceptance letter shall be given upon final inspection at the end of the one year warranty period, provided the work still complies with these specifications. In the event deficiencies are discovered during the warranty period, the Contractor shall correct them without additional charge to the Owner before final acceptance. During the warranty period, the A/E will determine if warranty repairs or replacement work shall be performed by the Contractor. The decision of the A/E shall be binding upon the Contractor. Contractor is responsible for returning to site and repairing any leaks or deficiencies found within year one. Repair includes, but is not limited to, locating, excavation, system repair/replacement, backfill, and surface restoration.

PART 2 PRODUCTS

2.01 POLYETHYLENE PIPE AND FITTINGS

A. Provide polyethylene pressure pipe manufactured from PE4710 high density polyethylene meeting AWWA C906 and ASTM F714 standards, DR11, iron pipe size (IPS), Polyethylene (PE) Plastic Pipe (SDR-PR) based on outside diameter or ASTM D3035, Polyethylene (PE) Plastic Pipe (DR-PR) based on controlled outside diameter. Resin shall meet the requirements of ASTM 3350.

B. Pipe shall be legibly marked, at intervals of no more than 5 feet, in accordance with the requirements of ASTM F714 and AWWA C906.

C. Where HDPE pipe is joined to HDPE pipe, it shall be by thermal butt fusion except as noted in Section E below where electro-fusion is permitted. Thermal butt fusion, per ASTM F2620, shall be accomplished in accordance with the pipe manufacturer and fusion equipment supplier specifications. Workers installing HDPE pipe shall have the necessary experience as stated in qualifications above, and have submitted necessary information as defined in submittals above.

D. Where HDPE pipe is joined to other materials, it shall be by means of flanged connections (flange adapters, transition fittings and back-up rings) designed for joining polyethylene pipe to another material. All such connections shall occur within accessible spaces within the proposed vaults and in accordance with the pipe manufacturer specifications.

E. Electro-fusion couplings are permitted on a limited basis at critical locations where butt fusion is not physically possible. Joints that are proposed to be electro-fusion joined shall be shown on the pipe fusion plan and shall be submitted to A/E for approval.

F. Qualification of Manufacturer: The Manufacturer shall have manufacturing and quality control facilities capable of producing and assuring the quality of the pipe and fittings required by these specifications. The Manufacturer's production facilities shall be open for inspection by the A/E or the Owner's designated representative. Qualified manufacturers shall be approved by the A/E.

G. Pipe Manufacturer: Pipe manufacturers that are qualified and approved are listed below:
   1. Performance Pipe, Division of Chevron Phillips Chemical Company, LP, Driscoplex 4100 Pipe, DR11
   2. PolyPipe, Polypipe GB50 PE4710 Pipe, DR11
   3. JM Eagle, JMM HDPE PE4710 Pipe, DR11
   4. A/E Approved Equal

H. Materials: Polyethylene pipe and fittings shall be produced from PE4710 high density polyethylene; and shall be listed in PPI (Plastics Pipe Institute) TR-4, Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compounds, with a standard grade rating of 1600 psi at 73°F. Certify that the materials used to manufacture pipe and fittings meet these requirements.

I. Fabricated Fittings: Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe in accordance with ASTM F2206. Directional fittings 16" IPS and larger such as elbows, tees, etc., shall have a plain end inlet for butt fusion and plain end directional outlets. Part drawings shall be submitted for the approval of the A/E.

J. Polyethylene Flange Adapters: Flange adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-end holder. The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blow-out.

K. Back-up Rings and Flange Bolts: Flange adapters shall be fitted with lap joint flanges pressure rated equal to or greater than the mating pipe. The lap joint flange bore shall be chamfered to provide clearance to the flange adapter radius. Flange bolts and nuts shall be Grade 2 or higher. Bolt pattern for flanges shall be per ANSI B16.5. Back up rings shall be carbon steel. Washers shall be Belville washers.

L. Pipe shall be legibly marked, at intervals of no more than 5 feet, in accordance with the requirements of ASTM F714 and AWWA C906.

2.02 HOT WATER INSULATION AND JACKETING

A. Hot water piping shall be prefabicated with factory installed insulation and jacketing. Design temperature shall be 116F and design pressure shall be 115psi.

B. Approved Manufacturers: Thermacor Process "Polycor", Perma-Pipe "Xtru-Therm", or Rovanco HDPE Jacketed System.

C. Insulation:
   1. Application Requirements: Insulation shall be factory applied. Insulate low-temperature heating water supply and return piping.
   2. Polyurethane Foam: Insulation shall be rigid, 90% minimum closed cell polyurethane with a minimum 2.0 lbs per cubic foot density, compressive strength of 30 psi (min.), and coefficient of thermal conductivity (k-value) of not higher than 0.16 Btu in./Hr. sq. ft.

degrees F. Manufacturer is to provide insulation thicknesses along with calculations showing that outer jacket temperatures are within the limits of the system.

Pipe Sizes	**Min. Thickness**
≤ 3″	1.5″
> 3.5″	2″

D. Outer Jacket: The outer jacket shall be High Density Polyethylene (HDPE) with a minimum wall thickness as listed below:

Pipe Sizes	**Min. Thickness**
≤ 12″	0.100″
> 12″ – 24″	0.125″
> 24″	0.150″

E. Field Joints: Field joints shall be provided by manufacturer, and shall be HDPE in equal to or greater thickness to the outer jacket. Field joints shall be fully waterproof and designed for submerged operation.

2.03 PRODUCT QUALITY CONTROL

A. The manufacturer of pipe, fittings, or appurtenances shall verify that all material being provided has been subjected to an established quality control program of inspection for incoming and outgoing materials. Incoming polyethylene materials shall be inspected for density, melt flow rate, and contamination. The cell classification properties of the material shall be certified and verified by the established program. Incoming materials shall be approved by Quality Control before processing into finished goods. The Pipe and injection molded fitting Manufacturer shall maintain ISO 9000:2001 certification at the facility/facilities producing the products.

B. All fabricated fittings shall be inspected for joint quality based upon provided datalog records and alignment.

2.04 COMPLIANCE TESTS

A. In case of conflict with Manufacturer's certifications, the Owner or A/E may request re-testing by the manufacturer or have re-tests performed by an outside testing service. All re-testing shall be at the requestor's expense, and shall be performed in accordance with the Specifications.

B. Installation shall be in accordance with Manufacturer's recommendations and this specification. All necessary precautions shall be taken to ensure a safe working environment in accordance with the applicable codes and standards.

PART 3 EXECUTION

3.01 INSTALLATION OF HIGH DENSITY POLYETHYLENE PRESSURE PIPE AND FITTINGS

A. Install all high density polyethylene (HDPE) pressure pipe as specified on plans or a method approved by the A/E and manufactures requirements prior to construction.

B. Install all high density polyethylene pressure pipe and fittings in accordance with Manufacturer's recommendations, and this specification. Take all necessary precautions to ensure a safe working environment in accordance with the applicable codes and standards.

C. Contractor shall schedule a “Underground Hydronic Piping” pre-construction meeting with the Project Manager, Owner, Engineer, and including all sub-contractors (participating in the utility installation) to review installation requirements. The meeting shall take place after all submittals have been approved, but prior to any utility installation/construction.

D. Remove standing water in the bottom of trench. Trench is to be dewatered continually do prevent unsuitable subgrade. If trench bottom becomes saturated, Contractor will be required to remediate base. Protect the ends of all exposed conduits within trench to prevent water intrusion. Refer to “DEWATERING” for further requirements.

E. Grade trench bottom to provide a smooth, firm, stable, and rock free foundation throughout the length of the piping system. Shape bottom of trench to fit bottom of piping. Fill unevenness with tamped sand backfill.

F. Installation of factory prefabricated pre-insulated piping system is to be in accordance with manufacturer’s installation manual. Deviations are not permitted unless authorized. Install piping straight and true to bear evenly on sand bedding material.
   1. Assemble carrier pipe and fittings according to manufacturer’s installation manual. Maintain proper alignment during assembly of joints.
   2. Bedding: Accurately grade trench bedding with a minimum of 6 inches of manufactured or natural sand. Backfill sand to a minimum of 6 inches above and below pipe. Lay bedding to firmly support pipe along entire route.

G. Install components with pressure rating equal to or greater than system operating pressure.

3.02 FUSION JOINING

A. Butt Fusion Joining - Make joints between plain end pipes and fittings by butt fusion using only procedures that are recommended by the pipe and fitting Manufacturer and ASTM F2620.
   1. Ensure that persons making butt fusion joints are certified according to the standards and have proven experience to make fusion welds following Manufacturer's recommended procedures.
   2. Maintain records of trained personnel, and certify that training was received not more than 12 months before commencing construction.
   3. External and internal beads resulting from butt fusion joining shall not be removed.

B. Use caution to protect the exposed butt ends of pipes from exposure to oils, greases, or hydrocarbons. Any pipe exposed to hydrocarbons of any type shall be cut-out and removed prior to butt fusion.

C. Electro-Fusion Joining – Electro-fusion joining shall be permitted only as specified in Section 2.1 E above. Electro-fusion joining shall be conducted in accordance with ASTM F1290, the electro-fusion fittings recommended joining procedures, and recommended electro-fusion control box or processor.

3.03 FLANGE JOINT CONNECTION JOINING

A. Polyethylene pipe and fittings may be joined to other materials by means of flanged connections (flange adapters, transition fittings and back-up rings) designed for joining polyethylene pipe to another material. Some type of flange adapter and back up rings shall be used and installed in accordance to the piping’s manufacturer. In no case shall flange connections be permitted in areas that will be direct buried and backfilled.

B. Install flange connections in accordance with the Manufacturer's recommended procedure and Plastic Pipe Institute (PPI) TN-38 “Bolt Torque for Polyethylene Flanged Joints”. Center and align flange faces to each other before assembling and tightening bolts. Do not use the flange bolts to draw the flanges into alignment. Lubricate bolt threads, and fit Belville washers under the flange nuts. Tighten bolts evenly according to the tightening pattern and torque step recommendations of the Manufacturer and PPI TN-38. At least one hour after initial assembly,

re-tighten flange connections following the tightening pattern and torque step recommendations of the Manufacturer and PPI TN-38.

C. Where connecting hot water piping to flange joints, contractor shall procure field insulating and jacketing kit from pre-insulated piping manufacturer to provide a fully insulated and protected connection.

3.04 INSTALLATION OF MECHANICAL TORQUE TYPE RESTRAINTS

A. Clean the socket and plain end of the carrier pipe. Lubricate the gasket and plain end as recommended by the manufacturer just prior to slipping the gasket onto the plain end for assembly. Place the gland on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end.

B. Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly.

C. Push the gland toward the socket and center it around the pipe with the gland lip against the gasket. Insert T-bolts and hand tighten nuts. Make deflection after joint assembly but before tightening bolts (maximum deflection is 50).

D. Tighten the T-bolts to the same torque recommended in AWWA C111. Tighten in an alternating manner maintaining the same gap between the gland and the face of the MJ bell at all points around the socket. Repeat the process until all bolts are within the approximate torque range. Use of a torque wrench is mandatory.

E. After correct assembly of the mechanical joint, bring all wedges in contact with the pipe surface by turning the torque actuating bolts in a clockwise direction until contact is made and the bolts are “hand tight”.

F. Tighten each actuating bolt by turning approximately 180 degrees in a clockwise direction, alternating between bolts until the breakway heads twist off. NEVER turn a single bolt over 180 degrees without alternating to another bolt.

3.05 FOUNDATION AND BEDDING

A. Lay pipe on grade and on a stable foundation. Remove unstable or mucky trench bottom soils, and install a 6-inch bedding of sand on the pipe bottom grade. Compaction rates should be as specified in ASTM D2321. Remove excess groundwater from the trench before laying the foundation or bedding and the pipe. Pipe shall be laid when the conditions of trench are dry. A trench cut in rock or stony soil shall be excavated to 6 inches below pipe bottom grade, and brought back to grade with bedding material noted above. Remove all ledge rock, boulders, and stones larger than 3 inches in any dimension from excavated trench prior to placing sand bedding and pipe.

3.06 PIPE HANDLING

A. When lifting with slings, use only wide fabric choker slings to lift, move, or lower pipe and fittings. Do not use wire rope or chain. Slings shall be of sufficient capacity for the load, and shall be inspected before use. Do not use worn or defective equipment.

B. At all times through delivery, storage, on-site staging and installation, the Contractor shall protect and ensure that the HDPE pipe is not exposed to liquid hydrocarbons. If any portions of the pipe are exposed to hydrocarbons, that section of pipe shall be cut-out and removed from use.

C. The Contractor shall exercise care in pipe handling. Gouges exceeding 10% of pipe wall thickness shall be cause for rejection of the pipe.

3.07 TRACER WIRE

A. Tracer wire shall be placed with all HDPE lines (supply and return) and shall be insulated, #10 solid copper core rated for underground service blue in color. The tracer wire shall be connected to all valves and underground vault chilled and hot water supply and return mains.

The buried sections of tracer wire shall be continuous. A five foot section, neatly coiled, of tracer wire shall be extended to the surface and terminate into a 11”x18” hand hole. Handhole shall have open bottom with HD (Tier 22) lid labeled TRACER, for all tracer wires. Provide 6” of 57 stone below handhole. Provide box at all branch connections and route tracer wire for main and branch into same box. Wires shall be tagged for each respective line. Where installed in pavement areas or landscape areas, install box 1” above normal pavement grade with pavement grade with pavement tapered away from box. Where installed in sidewalks, install flush with grade.

B. All splices or connections shall be made at accessible locations. All spliced or repaired wire connections in the tracer wire system shall be made using a Wing Nut Wire Connector (for two to four number ten wires), and made waterproof using an approved buried service wire closure.

C. The tracer wire shall be tested upon completion of the installation to ensure conductivity for locating. If any areas appear to be disconnected or conductivity appears incomplete, the tracer wire shall be excavated, inspected and replaced.

3.08 TESTING

A. Hydrostatic Pressure Testing: Pressure test HDPE pipes in accordance with ASTM F2164, “Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure”. Hydrostatic Testing of each section or sequence of pipe shall be performed prior to backfilling with all joints exposed. After pipe has been completely installed and backfilled the entire system shall be hydrostatically tested again. Test at 150 psig for two hours. Owner representative and/or Designer shall witness test. Prepare and submit report documenting testing for record. There will be no allowable leakage for fusion joined HDPE pipe.

3.09 CLEANING

A. Clean chilled and hot water piping as follows:
   1. Purge all new piping systems and parts of existing systems that have been altered, extended, or repaired, prior to use.
   2. Use the purging and disinfecting procedure prescribed by the authority having jurisdiction or, in case a method is not prescribed by that authority, use the procedure described in AWWA C651, or as described below:
      a. Contractor shall visually inspect internal portion of each length of pipe during installation. Remove all dirt and foreign matter prior to installing additional lengths. After each major section of piping has been installed, it shall be cleaned and flushed. Piping 8” and larger shall be flushed utilizing a “hydro-jet” process which involves passing a minimum 2000 PSI, minimum 50 GPM spray type cleaning head through the piping. The length of the piping section shall be determined ahead of time so that the proper amount of travel can be tracked with calibrated markings on the spray head feed water hose or a meter on the hose reel. For each section of piping the process shall be performed a minimum of two times and shall be repeated until the water exiting the end of the pipe is clear and free of debris as determined by the Owner/Engineer. Piping 6” and smaller shall be flushed using local hydrant if unable to pass spray type cleaning head through pipe. Coordinate with Owner for hydrant connection. A flush velocity of 6fps shall be obtained.
      b. All cleaning and flushing shall be performed such that all debris will be pulled or flushed downhill. All cleaning and flushing shall be initiated from all low points in the system and shall terminate at the nearest adjacent high point in the system.
      c. Coordinate the limitations and requirements of hydro-jet process with the flushing subcontractor such that the piping is installed in a sequence and manner that allows every section of the new pipeline to be cleaned and flushed. Limitations may include maximum length of the pipe section, maximum number and/or degree of bends in the pipe section, maximum slope of the pipe section, equipment and excavation access

requirements, and the minimum size of the openings required in the piping to allow for insertion and retraction of the cleaning head.

d. Contractor shall provide access at all low points through valves, tees, flanges, etc. to facilitate the cleaning and flushing process. If temporary fittings or piping is required it shall be provided by the Contractor and removed by the Contractor after successful cleaning.

e. After flushing and cleaning is completed, Contractor shall provide necessary pipe and fittings required to complete the piping system. Each cleaned section of piping shall be capped and protected to keep mud, debris, water, etc. from entering the piping. If a piping section is left open or unprotected, or is found to be contaminated, it shall be re-cleaned prior to being filled and activated at no cost to the Owner.

f. Contractor shall provide all water for flushing and testing. Coordinate rental of fire hydrant meters with local Fire Department(s), or the Owner as required.

g. Contractor shall provide all temporary piping from water source to piping system and shall provide means for conducting cleaning water from underground piping system to the appropriate sewer; i.e. pumps, piping, hoses, tanks, etc. Contractor to remove all temporary piping, pumps, hoses, etc. from site immediately after flushing has been completed. Flushing water shall be discharged without causing damage, nuisance, or interruption of traffic. Disposal of flushing water shall be to the sanitary sewer system.

3. Prepare reports for all purging activities.

END OF SECTION

SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes special-duty valves and specialties for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Makeup-water piping.
   4. Condensate-drain piping.
   5. Blowdown-drain piping.
   6. Air-vent piping.
   7. Safety-valve-inlet and -outlet piping.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   2. Air-control devices.
   3. Hydronic specialties.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.04 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.05 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.06 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Hot-Water Heating Piping: 150 psi at 200 deg F.
   2. Chilled-Water Piping: 150 psig at 200 deg F.
   3. Makeup-Water Piping: 80 psig at 150 deg F.
   4. Condensate-Drain Piping: 150 deg F.
   5. Blowdown-Drain Piping: 200 deg F.
   6. Air-Vent Piping: 200 deg F.
   7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.02 VALVES

A. Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 00 "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett Domestic Pump.
      c. Flow Design Inc.
      d. Gerand Engineering Co.
      e. Griswold Controls.
      f. Nexus Valve, Inc.
      g. Taco.
      h. Tour & Andersson; available through Victaulic Company.
   2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   3. Ball: Brass or stainless steel.
   4. Plug: Resin.
   5. Seat: PTFE.
   6. End Connections: Threaded or socket.
   7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   8. Handle Style: Lever, with memory stop to retain set position.
   9. CWP Rating: Minimum 125 psig.
   10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett Domestic Pump.
      c. Flow Design Inc.
      d. Gerand Engineering Co.
      e. Griswold Controls.
      f. Nexus Valve, Inc.
      g. Taco.
      h. Tour & Andersson.
   2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
   3. Ball: Brass or stainless steel.
   4. Stem Seals: EPDM O-rings.
   5. Disc: Glass and carbon-filled PTFE.
   6. Seat: PTFE.
   7. End Connections: Flanged or grooved.
   8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   9. Handle Style: Lever, with memory stop to retain set position.
   10. CWP Rating: Minimum 125 psig.
   11. Maximum Operating Temperature: 250 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMTROL, Inc.
      b. Armstrong Pumps, Inc.
      c. Bell & Gossett Domestic Pump.
      d. Conbraco Industries, Inc.
      e. Spence Engineering Company, Inc.
      f. Watts Regulator Co.
   2. Body: Bronze or brass.
   3. Disc: Glass and carbon-filled PTFE.

4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flow Design Inc.
b. Griswold Controls.
c. Nexus Valve, Inc.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.

2.03 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.
e. Taco, Inc.
2. Body: Bronze.
3. Internal Parts: Nonferrous.

4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Nexus Valve, Inc.
   e. Taco, Inc.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Bladder-Type Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.
   e. Patterson.
2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
5. Provide tank mounted pressure monitors with audible and LED alarms for all bladder type expansion tanks.

D. Tangential-Type Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.
   e. Patterson.
2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

E. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.04 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
   4. CWP Rating: 125 psig.

B. Basket Strainers:
   1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 125 psig.

C. T-Pattern Strainers:
   1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
   2. End Connections: Grooved ends.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
   4. CWP Rating: 750 psig.

D. Stainless-Steel Bellow, Flexible Connectors:
   1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
   2. End Connections: Threaded or flanged to match equipment connected.
   3. Performance: Capable of 3/4-inch misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

E. Spherical, Rubber, Flexible Connectors:
   1. Body: Fiber-reinforced rubber body.
   2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   3. Performance: Capable of misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

F. Expansion Fittings: Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping."

PART 3 EXECUTION

3.01 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.02 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install tangential air separator in pump suction. Install blowdown piping with full-port ball valve; extend full size to nearest floor drain.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

F. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm’s length.

END OF SECTION

SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Close-coupled, inline centrifugal pumps.
   2. Separately-coupled, end-suction centrifugal pumps.
   3. Automatic condensate pump units.
   4. Pump specialty fittings.

1.02 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.
   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, maintenance manuals and laser alignment reports.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seal for each pump.

1.06 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett e-80, e-90 or comparable product by one of the following:
   1. Armstrong Pumps, Inc
   2. Bell & Gossett; a Xylem brand
   3. Patterson Pump Company; a Gorman-Rupp company
   4. TACO Comfort Solutions, Inc

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:
   1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded (2” and smaller) or companion-flange (2-1/2” and larger) connections.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT/EPR bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
a. Enclosure: Open, dripproof.
b. Enclosure Materials: Cast iron.
c. Motor Bearings: Permanently lubricated or grease-lubricated ball bearings.
d. Efficiency: Premium efficient.

2.02 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett e-1510 or comparable product by one of the following:
1. Armstrong Pumps, Inc
2. Bell & Gossett; a Xylem brand
3. Patterson Pump Company; a Gorman-Rupp company
4. TACO Comfort Solutions, Inc

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:
1. Casing: Vertically split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel, or SAE1144 steel with stainless steel shaft sleeve. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket.
5. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   a. Enclosure: Open, dripproof.
   b. Enclosure Materials: Cast iron.
   c. Motor Bearings: Grease-lubricated ball bearings.
   d. Efficiency: Premium efficient.

2.03 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Beckett Corporation
   2. Hartell Pumps; Milton Roy
   3. Little Giant Pump Co
   4. Mepco, LLC

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls.

C. Include external overflow safety switch, external test/run switch, factory- installed check valve on outlet and a 72-inch- minimum, electrical power cord with plug.

2.04 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong Pumps, Inc
      b. Bell & Gossett; a Xylem brand
      c. TACO Comfort Solutions, Inc.
   2. Angle pattern.
   3. 175-psig pressure rating, ductile-iron or cast iron body and end cap, pump-inlet fitting.
   4. Strainers:
      a. Water Service startup: 20-mesh, bronze
      b. Water Service up to 2 inches: 20-mesh, stainless-steel
      c. Water Service 2-1/2 inches to 4 inches: 1/16 inch perforations, stainless-steel
      d. Water Service 6 inches and larger: 1/8 inch perforations, stainless-steel
   5. Bronze or stainless-steel straightening vanes.
   6. Grooved system connection, flanged pump connection.
   7. Drain plug.
   8. Pressure/Temperature port.
   9. Factory-fabricated adjustable support.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:
   1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations.
   2. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration Controls for HVAC."

3.03 ALIGNMENT

A. Engage a factory-authorized service representative to perform laser alignment service. Provide a report for close-out documentation.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.04 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check and shutoff valves on discharge side of pumps.

F. Install Y-type strainer and shutoff valve on suction side of pumps.
   1. Provide suction diffuser and shutoff valve on suction side of end-suction pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install single pressure gage with multiple-input selector valve on pump suction and discharge and across suction diffuser/strainer.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.05 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

SECTION 23 22 13 - STEAM AND CONDENSATE HEATING PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes pipe and fittings for LP and HP steam and condensate piping:
   1. Steel pipe and fittings.
   2. Joining materials.

1.02 DEFINITIONS

A. LP: Low pressure; 15 psig and below.

B. HP: High pressure; 16 psig and above.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Steel pipe and fitting.
   2. Joining material.

B. Delegated-Design Submittal:
   1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
   2. Locations of pipe anchors and alignment guides and expansion joints and loops.

1.04 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding: Qualify procedures and operators according to the following:
   1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. HP Steam and Condensate Piping: 250 psig at 350 degF
   2. LP Steam and Condensate Piping: 150 psig at 250 degF.
   3. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
   4. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
   5. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.02 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.03 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

D. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

E. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

F. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.04 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
   1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
   2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

V. Install sleeves for piping penetrations of walls, ceilings, and floors.

W. Install sleeve seals for piping penetrations of exterior concrete walls and slabs.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.02 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 23 22 16 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.03 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers and supports. Comply with requirements below for maximum spacing.

B. Comply with requirements in Section 23 05 48 "Vibration Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply and condensate piping with the following maximum spacing:
1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.04 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.05 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.06 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests and inspections:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump,

valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.

3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

C. Prepare test and inspection reports.

D. Provide minimum 48 hours notice prior to testing to allow the Architect, Engineer, Commissioning Agent, Owner or his representative the opportunity to attend.

E. Tests shall be conducted and written report of testing submitted before any insulation is installed. Insulation installed prior to tests shall be removed.

3.07 LP STEAM PIPING SCHEDULE

A. LP Steam Piping, NPS 2 and Smaller:
1. Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 and Larger:
1. Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and Smaller:
1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and Larger:
1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.08 HP STEAM PIPING SCHEDULE

A. HP Steam Piping, NPS 2 and Smaller:
1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. HP Steam Piping, NPS 2-1/2 and Larger:
1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and Smaller:
1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and Larger:
1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.09 ANCILLARY PIPING SCHEDULE

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

END OF SECTION

SECTION 23 22 16 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:
   1. Strainers..
   2. Steam traps.
   3. Thermostatic air vents and vacuum breakers.
   4. Flexible connectors.

1.02 DEFINITIONS

A. LP: Low pressure; 15 psig and below.

B. HP: High pressure; 16 psig and above.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Strainers.
   2. Valves.
   3. Steam traps.
   4. Air vent and vacuum breakers.
   5. Connectors.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:
   1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. HP Steam and Condensate Piping: 250 psig at 350 degF
   2. LP Steam and Condensate Piping: 150 psig at 250 degF.
   3. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
   4. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
   5. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.02 VALVES

A. Ball, Butterfly, Check, Globe and Gate Valves: Comply with requirements specified in Section 23 05 23 "General Duty Valves for HVAC Piping."

2.03 STRAINERS

A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

B. Basket Strainers:
1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 250-psig working steam pressure.

2.04 STEAM TRAPS

A. Float and Thermostatic Steam Traps:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong International, Inc
b. Hoffman Specialty
c. Spirax Sarco, Inc
2. Body and Bolted Cap: ASTM A 126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.
11. Universal strainer connector with blowdown (parallel connection).

B. Universal Connectors:
1. Stainless steel pipeline connector with integral strainer & blowdown.

2.05 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong International, Inc
b. Hoffman Specialty
c. Spirax Sarco, Inc
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong International, Inc
b. Hoffman Specialty
c. Spirax Sarco, Inc

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 deg F.

2.06 FLEXIBLE CONNECTORS

A. Stainless-Steel Bellows, Flexible Connectors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Duraflex, Inc.
      b. Mason Industries, Inc.
      c. Metraflex Company (The)
      d. Twin City Hose, Inc.
   2. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
   3. End Connections: Threaded or flanged to match equipment connected.
   4. Performance: Capable of 3/4-inch misalignment.
   5. CWP Rating: 250 psig.
   6. Maximum Operating Temperature: 250 deg F.

2.07 PIPING SPECIALTY INSULATION JACKETS

A. Provide factory fabricated insulation jackets for steam specialty equipment equal to Spirax Sarco IJ.

B. Steam specialty equipment shall include steam and condensate valves, strainers, safety valves, inverted bucket steam traps, float & thermostatic steam traps, pipeline connectors, etc.
   1. Inner and outer cover surface: Silicone rubber coated glass fiber
   2. Insulation: Mineral fiber
   3. Stitching: Nylon
   4. Fastening: Velcro
   5. Draw cords: Nylon
   6. Label: Cotton.

PART 3 EXECUTION

3.01 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.02 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

D. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

G. Install strainers parallel to the floor to prevent the accumulation of condensate in the strainer body.

3.03 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.04 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps in accessible locations close to connected equipment.

B. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.02 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig.
   2. Suction Lines for Heat-Pump Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Filter dryers.
   4. Strainers.
   5. Pressure-regulating valves.

1.04 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.07 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 PRODUCTS

2.01 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.02 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Flanged Unions:
1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
6. Pressure Rating: Factory test at minimum 400 psig.
7. Maximum Operating Temperature: 330 deg F.

F. Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:
   a. NPS 2and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.03 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
   1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
   3. Piston: Removable polytetrafluoroethylene seat.
   4. Closing Spring: Stainless steel.
   5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
   6. End Connections: Socket, union, threaded, or flanged.
   7. Maximum Opening Pressure: 0.50 psig.
   8. Working Pressure Rating: 500 psig.
   9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Copper spring.
   5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
   6. Working Pressure Rating: 400 psig.
   7. Maximum Operating Temperature: 240 deg F.
   8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   2. Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Seat Disc: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Working Pressure Rating: 400 psig.
   6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.
   1. Body, Bonnet, and Seal Cap: Forged brass or steel.
   2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Packing and Gaskets: Non-asbestos.
   4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   5. Suction Temperature: 40 deg F.
   6. Superheat: Nonadjustable.
   7. Reverse-flow option (for heat-pump applications).
   8. End Connections: Socket, flare, or threaded union.
   9. Working Pressure Rating: 450 psig.

H. Straight-Type Strainers:
   1. Body: Welded steel with corrosion-resistant coating.
   2. Screen: 100-mesh stainless steel.
   3. End Connections: Socket or flare.
   4. Working Pressure Rating: 500 psig.
   5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:
   1. Body: Forged brass or cast bronze.
   2. Drain Plug: Brass hex plug.

3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

L. Permanent Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS ¼ connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

M. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

N. Receivers: Comply with ARI 495.
1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

O. Liquid Accumulators: Comply with ARI 495.
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.04 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Atofina Chemicals, Inc.
   2. DuPont Company; Fluorochemicals Div.
   3. Honeywell, Inc.; Genetron Refrigerants.
   4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.02 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.03 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to the latest version of ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 13 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 23 05 53 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.04 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.05 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
   2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.

3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. Support multifloor vertical runs at least at each floor.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
a. Fill system with nitrogen to the required test pressure.
b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.07 SYSTEM CHARGING

A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.08 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 25 13 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:
   1. Flushing.
   2. Chemicals.

1.02 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

B. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.03 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
   1. Flushing procedures

1.04 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Other Informational Submittals:
   1. Water Analysis: Illustrate water quality available at Project site and the final water condition in the piping system at turnover.

1.05 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Chemicals for close loop systems, furnish additional quantity equal to 100% of amount initially installed.

1.06 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities and applying water treatment as specified in this Section.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aqua-Chem, Inc.
   2. Barclay Water Management, Inc
   3. Boland Trane Services
   4. Cascade Water Services, Inc
   5. Earthwise Environmental Inc
   6. H-O-H Water Technology, Inc
   7. Metro Group, Inc. (The)
   8. Nalco; an Ecolab company
   9. Water Services Inc

2.02 PERFORMANCE REQUIREMENTS

A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including heating hot-water heating and chilled water, shall have the following water qualities:
   1. pH: Maintain a value within 9.0 to 10.5.
   2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
   3. Boron: Maintain a value within 100 to 200 ppm.
   4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm (for systems without glycol).
   5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
   6. TSS: Maintain a maximum value of 10 ppm.
   7. Ammonia: Maintain a maximum value of 20 ppm.
   8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
   9. Microbiological Limits:
      a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
      b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
      c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
      d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
      e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.03 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

B. Chemicals used shall be similar to what is currently used at the WTCC Eastern Wake Site CEP.

PART 3 EXECUTION

3.01 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.02 FIELD QUALITY CONTROL

A. Preoperational System Cleanout:
   1. The campus has a central chilled water and heating hot water distribution system with bypasses for each in the building’s main mechanical room. The owner will be responsible for chemical treatment on the central plant side of the bypass. The flushing and cleaning requirements in the specification section apply to all piping on the building side of the bypass and must be completed, tested and inspected prior to opening valves between the central plant and building. Once the system is turned over to the owner, all future chemical treatment of the building hydronic systems will be performed in the CEP.
   2. At pipe end locations a temporary bypass shall be installed. Bypass shall be same size as the supply and return pipe. Prior to flushing the distribution system, install the temporary bypass and a temporary line size strainer between the supply and return pipes. Verify that the isolation valves are open.
   3. After the temporary bypasses are installed, provide and operate one temporary pump which will cause a velocity of 10 feet per second in the main piping. This pump will be provided with a shot chemical feeder and a strainer assembly. Pump shall be connected to system.

4. Circulation shall be started using the temporary pump. A nonhazardous cleaning compound (Entec 324 or approved equal) shall be added using a temporary shot feeder until the concentration level of 20 parts per million is reached. Once this 20 parts per million concentration is reached, circulation shall be maintained for 48 hours. After this period of time, the cleaning water shall be dumped to the sanitary sewer.
5. The distribution system shall then be refilled with city water and circulated with continual bleed and make-up until the water is certified clean by the water treatment consultant, and accepted by the Owner. At the completion of this step an inhibitor shall be introduced. All waste water shall be dumped into the sanitary sewer system.
6. After the system is certified as clean close the valves. The bypass piping shall be removed as final connections to the building are accomplished.
7. During the flushing procedure, strainers shall be cleaned as often as necessary to remove debris and, in any event, all strainers shall be cleaned by physically removing the strainer screen from the body of the strainer at the end of flushing. Replace strainer basket and gasket. Do not flush through control valves, coils, etc. Provide temporary bypasses at coils and spool pieces at control valves. Flush the coils individually wasting water to sanitary sewer. Connect coils and install control valves after flushing.
8. Test samples shall be taken at all bypass locations and all tests shall indicate that the entire system has reached the approved pH, conductivity, and chemical concentration 1evel.
9. Provide a smaller assembly to clean and flush any miscellaneous piping that cannot be included in the initial system flush. All other criteria shall remain the same.
10. Submit a cleaning and flushing report. The report shall include the Date, Time, and duration of the tests with a schematic drawing of the piping that was cleaned and flushed. The report shall also include what chemicals were used, what tests were performed and the results. The report shall be signed by contractor and water treatment consultant.
    a. Cleaning and flushing report shall be submitted to Skanska prior to opening building valves and allowing mixing with WTCC Eastern Wake Site CEP.

B. Comply with ASTM D 3370 and with the following standards:
1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

END OF SECTION

SECTION 23 31 13 - METAL DUCTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   3. Double-wall round ducts and fittings.
   4. Sheet metal materials.
   5. Sealants and gaskets.
   6. Hangers and supports.

1.02 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.
   3. Seismic-restraint devices.

B. Sustainability Submittals:
   1. Product Data: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
   2. Product Data: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
   3. Leakage Test Report: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
   4. Duct-Cleaning Test Report: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
   5. Product Data: For adhesives and sealants, documentation including printed statement of VOC content.
   6. Laboratory Test Reports: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

B. Welding certificates.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
   3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Lindab Inc.
      b. McGill AirFlow LLC.
      c. SEMCO Incorporated.
      d. Sheet Metal Connectors, Inc.
      e. Spiral Manufacturing Co., Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eastern Sheet Metal, Inc.
2. Linx Industries (formerly Lindab)
3. McGill AirFlow LLC
4. MKT Metal Manufacturing
5. SEMCO LLC
6. Set Duct Manufacturing
7. Sheet Metal Connectors, Inc.
8. Turnkey Duct Systems

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch solid sheet steel.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.

F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
   1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at75 deg F mean temperature.

2.04 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Factory- or Shop-Applied Antimicrobial Coating:
   1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
   2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
   4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   5. Shop-Applied Coating Color: Black.
   6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.05 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 4 inches.
   3. Sealant: Modified styrene acrylic.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
12. Service: Indoor or outdoor.
13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

PART 3 EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class A.
4. Outdoor, Return-Air Ducts: Seal Class A.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class A.
8. Unconditioned Space, Return-Air Ducts: Seal Class A.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
11. Conditioned Space, Exhaust Ducts: Seal Class A.
12. Conditioned Space, Return-Air Ducts: Seal Class A.

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.05 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.06 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.07 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:
      a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
      b. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
      c. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
      d. Exhaust Ducts with a Pressure Class of 2-Inch wgor Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
      e. Outdoor Air Ducts with a Pressure Class of 2-Inch or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Test for leaks before applying external insulation.
   5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
   6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.08 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
   1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch

insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.09 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:
1. Ducts Connected to Multi-Zone Air-Handling Units, downstream, from air handling units to terminal units:
a. Concealed: Single wall, round, oval or rectangular as shown on drawings.
b. Exposed to View (installed within occupied areas): Double wall, round, oval or rectangular as shown on drawings.

c. Pressure Class: Positive 4-inch wg.
d. SMACNA Seal Class: A.
e. SMACNA Leakage Class for Rectangular: 4.
f. SMACNA Leakage Class for Round and Flat Oval: 2.

2. Ducts Connected to Single-Zone Air-Handling Units, downstream, from air handling units to air de-vice:
   a. Concealed: Single wall, round, oval or rectangular as shown on drawings.
   b. Exposed to View (installed within occupied areas): Double wall, round, oval or rectangular as shown on drawings.
   c. Pressure Class: Positive 2-inch wg.
   d. SMACNA Seal Class: A.
   e. SMACNA Leakage Class for Rectangular: 4.
   f. SMACNA Leakage Class for Round and Flat Oval: 2.
3. Ducts Connected to Terminal Units/Air Valves, downstream, from unit to air device:
   a. Concealed: Single wall, round, oval or rectangular as shown on drawings.
   b. Exposed to View (installed within occupied areas): Double wall, round, oval or rectangular as shown on drawings.
   c. Pressure Class: Positive 2-inch wg.
   d. SMACNA Seal Class: A.
   e. SMACNA Leakage Class for Rectangular: 4.
   f. SMACNA Leakage Class for Round and Flat Oval: 2.

C. Return Ducts:
1. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round and Flat Oval: 2.
2. Ducts Connected to Fan Coil Units and Terminal Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round and Flat Oval: 2.

D. Exhaust Ducts:
1. Exhaust Ducts Connected to Fans Exhausting General and Toilet Air (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round and Flat Oval: 2.
2. LEF-1/2 Exhaust System: Main and Branch Ducts:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round and Flat Oval: 2.
3. LEF-3/4 Exhaust System: Laboratory Main Ducts, and Laboratory Branch Ducts Not Connected to Laboratory Fume Hoods/Containment Devices:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 4.
   d. SMACNA Leakage Class for Round and Flat Oval: 2.
4. LEF-3/4 Exhaust System: Laboratory Branch Ducts Connected to Laboratory Fume Hoods/Containment Devices, From Fume Hood to Laboratory Exhaust Air Valve, and from Laboratory Exhaust Air Valve to Laboratory Duct Main:
   a. Single wall, round, oval or rectangular as shown on drawings.

b. Material: Type 304, stainless-steel sheet.
1) Exposed to View: No. 4 finish.
2) Concealed: No. 2D finish.
c. Pressure Class: Negative 4-inch wg.
d. Welded seams, joints, and penetrations.
e. Airtight/Watertight.

5. Ducts Connected to Equipment Not Listed Above:
a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 2.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Air-Handling Units:
a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 2.
2. Ducts Connected to Equipment Not Listed Above:
a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 2.

F. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:
a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

G. Double-Wall Duct Interstitial Insulation:
1) Flexible elastomeric, 1-1/2 inches thick. Thermal conductivity (k-value) at 75 deg F shall be 0.28 Btu x in./h x sq. ft. x deg F or less. Minimum installed R-Value of 6.0.

H. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
a. Velocity 1000 fpm or Lower:
1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.
b. Velocity 1000 to 1500 fpm:
1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
c. Velocity 1500 fpm or Higher:
1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

I. Branch Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
      a. Rectangular Main to Rectangular Branch: 45-degree entry.
      b. Rectangular Main to Round Branch: Spin in.
   2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
      a. Velocity 1000 fpm or Lower: 90-degree tap.
      b. Velocity 1000 to 1500 fpm: Conical tap.
      c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Backdraft dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Duct silencers.
8. Turning vanes.
9. Remote damper operators.
10. Duct-mounted access doors.
11. Flexible connectors.
12. Flexible ducts.
13. Duct accessory hardware.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Sustainability Submittals:
1. Product Data: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Wiring Diagrams: For power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 PRODUCTS

2.01 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 22, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 BACKDRAFT DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. American Warming and Ventilating; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   4. Greenheck Fan Corporation.
   5. Lloyd Industries, Inc.
   6. Nailor Industries Inc.
   7. NCA Manufacturing, Inc.
   8. Pottorff.
   9. Ruskin Company.
   10. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 1-inch wg.

E. Frame: Hat-shaped, 0.05-inch thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch- thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Felt

I. Blade Axles:
   1. Material: Nonferrous metal
   2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:
1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
   a. Sleeve Thickness: 20 gage minimum.
   b. Sleeve Length: 6 inches minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel.
8. Screen Type: Bird.
9. 90-degree stops.

2.04 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Warming and Ventilating; a Mestek Architectural Group company
   b. McGill AirFlow LLC
   c. Nailor Industries Inc
   d. NCA Manufacturing, Inc; a division of Metal Industries Inc.
   e. Pottorff
   f. Ruskin Company
   g. Trox USA Inc.
   h. United Enertech
   i. Vent Products Co., Inc
2. Performance:
   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure
3. Construction:
   a. Linkage outside of airstream.
   b. Suitable for horizontal or vertical applications.
4. Frames:
   a. Hat-shaped, 16-gauge- thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 16 gauge thick.
6. Blade Axles: Galvanized steel, hex.
7. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

2.05 CONTROL DAMPERS

A. The BAS Contractor shall furnish all automatic control dampers, unless located within and provided as part of a factory furnished air handling unit. All automatic dampers shall be sized for the application by the BAS Contractor or as specifically indicated on the Drawings.

2.06 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. Arrow United Industries; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   4. Greenheck Fan Corporation.
   5. Nailor Industries Inc.
   6. NCA Manufacturing, Inc.
   7. Pottorff.
   8. Prefco; Perfect Air Control, Inc.
   9. Ruskin Company.
   10. Vent Products Company, Inc.
   11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and maximum 2000-fpm velocity.

D. Fire Rating: 1-1/2 hours. 3-hour dampers shall be installed where required by wall or floor rating.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.05 inch thick, as indicated, and of length to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

K. Heat-Responsive Device: Electric link and switch package, factory installed, 165 deg F rated.

2.07 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. Cesco Products; a division of Mestek, Inc.
   3. Greenheck Fan Corporation.
   4. Nailor Industries Inc.
   5. Pottorff.
   6. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094-inch thick, galvanized sheet steel, with welded corners and mounting flange.

E. Blades: Roll-formed, horizontal, interlocking 0.034-inch thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05-inch thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 23 09 00 "Instrumentation and Control for HVAC."
   3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
   5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
   6. Nonspring-Return Motors: For dampers larger than 25 sq. ft, size motor for running torque rating of 150 in. x lbfand breakaway torque rating of 300 in. x lbf.
   7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:
   1. Auxiliary switches for signaling position indication.
   2. Provide addressable duct smoke detector.
   3. Provide dampers with actuators that can be remotely reset by the fire alarm control panel.
   4. Test and reset switches: Damper mounted if easily accessible, otherwise remote mounted.
   5. Designed to close upon loss of power.

2.08 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Nexus PDQ; Division of Shilco Holdings Inc.
   3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.09 DUCT SILENCERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Vibro-Acoustics RD-MV-F1 or comparable product by one of the following:
   1. Dynasonics.
   2. Industrial Noise Control, Inc.
   3. McGill AirFlow LLC.
   4. Ruskin Company.

B. General Requirements:
   1. Factory fabricated.
   2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. 60” long rectangular straight with splitters or baffles on supply and return of each air handler.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G60, galvanized sheet steel, 0.034 inch thick.
   1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
   2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
   3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
   4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

E. Inner Casing and Baffles: ASTM A 653/A 653M, G60 galvanized sheet metal, 0.034 inch thick, and with diameter perforations.

F. Special Construction:
   1. High transmission loss (reduce from calculated value (NC-50) to design criteria value (NC-25)

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
   1. Joints: Lock formed and sealed continuously welded or flanged connections.
   2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   3. Reinforcement: Cross or trapeze angles for rigid suspension.

I. Accessories:
   1. Factory-installed end caps to prevent contamination during shipping.
   2. Removable splitters.
   3. Airflow measuring devices.

J. Source Quality Control: Test according to ASTM E 477.
   1. Testing to be witnessed by Owner.
   2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
   3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.10 AIR TRANSFER SILENCERS

A. Return Air Canopy
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Price RAC or comparable product by one of the following:
      a. Commercial Acoustics
      b. Dynasonics
      c. Flex-Tek Group
      d. Industrial Noise Control, Inc
      e. McGill AirFlow LLC
      f. Price
      g. Ruskin Company
   2. General:
      a. Furnish and install return air canopy air transfer silencers of the size, configuration, and acoustic performance as described on the plans and schedules.
   3. Performance:
      a. Return air canopy performance characteristics, including insertion loss and pressure drop, shall be attained through testing in accordance with ASTM Standard E477.
      b. Laboratory performance verification in the manufacturer’s test facility may be requested, in which case a comparative test report shall be made available to the engineer.
   4. Construction:

a. Return air canopies shall be constructed in accordance with ASHRAE and SMACNA Standards for the pressure and velocity classification specified for the air distribution system in which it is installed.
b. Return air canopies shall be constructed of:
   1) 24 gauge solid steel casing
   2) Acoustic media:
      a) Fiber free foam liner.
c. Acoustic media:
   1) Fiber free foam:
      a) Fiber free foam shall be self-sealing engineered foam that will not expose fibers to the airstream.
      b) Fiber free foam shall be in accordance with erosion requirements of UL 181, and shall conform to the physical properties and requirements of ASTM C1071.
      c) Mold growth and humidity requirements shall be in accordance with ASHRAE Standard 62.1.
d. Fire-Performance Characteristics:
   1) Air transfer silencer assemblies, including acoustic media fill, sealants, and acoustical spacers shall have combustion rating equal to or less than shown below when tested according to ASTM E84, NFPA 255 or UL 723:
      a) Flame-spread index not exceeding 25
      b) Smoke-developed index not exceeding 50

2.11 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Elgen Manufacturing.
   4. METALAIRE, Inc.
   5. SEMCO Incorporated.
   6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

2.12 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Pottorff.
   2. Ventfabrics, Inc.
   3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass .

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed

F. Wall-Box Cover-Plate Material: Stainless steel.

2.13 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating; a division of Mestek, Inc.
   2. Cesco Products; a division of Mestek, Inc.
   3. Ductmate Industries, Inc.
   4. Elgen Manufacturing.
   5. Flexmaster U.S.A., Inc.
   6. Greenheck Fan Corporation.
   7. McGill AirFlow LLC.
   8. Nailor Industries Inc.
   9. Pottorff.
   10. Ventfabrics, Inc.
   11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. Vision panel.
      d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
      e. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   3. Number of Hinges and Locks:
      a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
      b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
      c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
      d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.14 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Flame Gard, Inc.
   3. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.15 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Elgen Manufacturing.
   4. Ventfabrics, Inc.
   5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

F. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating, weatherproof, resistant to UV rays and ozone.
   1. Minimum Weight: 14 oz./sq. yd..
   2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
   3. Service Temperature: Minus 67 to plus 500 deg F.

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.16 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flexmaster U.S.A., Inc.
   2. McGill AirFlow LLC.
   3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated, Acoustical Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
   1. Pressure Rating: 6-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 to plus 175 deg F.
   4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

D. Flexible Duct Elbow Supports:
   1. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.
   2. Classified: UL 2043.
   3. Material: 100 percent recycled copolymer polypropylene.
   4. Support Frame Radius: 8 inches.
   5. Compliance for Flexible Duct Radius:
      a. SMACNA HVAC Duct Construction Standards.
      b. ASHRAE Advanced Energy Design Guides.

c. ADC Flexible Duct Performance and Installation Standards.

2.17 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers in exhaust ductwork:
   1. For rooftop and base mounted fans, install damper at inlet of exhaust fans or in the exhaust duct close to exhaust fan unless otherwise indicated.
   2. For in-line exhaust fans, install damper in exhaust duct downstream of fan as close as possible to exhaust plenum/louver unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts.
   1. Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.
   3. Install stainless steel volume dampers in stainless steel ducts.

E. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel

F. Mark the locations of all above-ceiling duct mounted dampers with orange non-adhesive surveyors flagging tape.

G. Set dampers to fully open position before testing, adjusting, and balancing.

H. Install test holes at fan inlets and outlets and elsewhere as indicated.

I. Install fire and smoke dampers according to UL listing.

J. Duct Smoke Detectors:
   1. HVAC duct smoke detectors shall be furnished as specified elsewhere by Division 28 for installation under Division 23. All wiring for air duct detectors shall be provided under Division 28.
   2. Comply with NFPA 72 and IMC. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
   3. Verify proper length and orientation on the sampling tube. Confirm the sampling tube protrudes into the duct in accordance with system design and per manufacturer's instructions.
   4. Verify the smoke detector is rigidly mounted. Confirm that no penetrations in a return air duct exist in the vicinity of the detector. Confirm the detector is installed so as to sample the airstream at the proper location in the duct.
   5. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
   6. Where duct detectors are used to initiate the operation of smoke dampers, they should be located so that the detector is between the last inlet or outlet upstream of the damper and the first inlet or outlet downstream of the damper.

K. Connect ducts to duct silencers rigidly.

L. Return air canopy silencer shall be provided on all non-ducted return air grilles.

M. Fire and Smoke Damper Access and Identification
   1. Fire and smoke dampers shall be provided with an approved means of access, large enough to permit inspection and maintenance of the damper and its operating parts.
   2. The access shall not affect the integrity of fire-resistance-rated assemblies.
   3. Access points shall be permanently identified on the exterior by a label having letters not less than 0.5 inch in height reading: FIRE/SMOKE DAMPER, SMOKE DAMPER or FIRE DAMPER.
   4. Access doors in ducts shall be tight fitting and suitable for the required duct construction.

N. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream and downstream from turning vanes.
   9. Upstream or downstream from duct silencers.
   10. Control devices requiring inspection.
   11. Elsewhere as indicated.

O. Install access doors with swing against duct static pressure.

P. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.
   3. Head and Hand Access: 18 by 10 inches.
   4. Head and Shoulders Access: 21 by 14 inches.
   5. Body Access: 25 by 14 inches.
   6. Body plus Ladder Access: 25 by 17 inches.

Q. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

R. Install flexible connectors to connect ducts to equipment.

S. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

T. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

U. Connect diffusers to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

V. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

W. Make bends in flexible ducts with minimum of 1-duct diameter centerline radius.

X. Where flexible ductwork is used as an elbow, provide flexible, durable duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions.

Y. Install duct test holes where required for testing and balancing purposes.

Z. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

AA. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm's length.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.
   5. Operate remote damper operators to verify full range of movement of operator and damper.
   6. Test duct smoke detectors per NFPA 72. Detectors that use sampling tubes shall be tested to ensure that they will properly sample the airstream in the duct using a method acceptable to the manufacturer or in accordance with their published instructions. Preferred method is to use a manometer to measure the differential pressure between the two sampling tubes. Verifying the differential pressure is within the manufacturer documented acceptable levels.
   7. Test all new fire and smoke dampers both at project completion as well as at the end of the one-year warranty period. Contractor shall provide the test results for both tests on the standard damper testing form.

END OF SECTION

SECTION 23 34 23 - HVAC FANS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. HVAC Fans.

1.02 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

C. UL Standard: Power ventilators shall comply with UL 705.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation.

B. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer’s instructions. For long term storage follow manufacturer's Installation, Operations, and Maintenance Manual.

C. Handling: Handle and lift fans in accordance with the manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

1.07 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Belts: One set(s) for each belt-driven unit.

1.09 WARRANTY

A. Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under Contract Documents.
   1. The warranty of this equipment is to be free from defects in material and workmanship for a period of one year from the purchase date. Any units or parts which prove defective during the warranty period will be replaced at the Manufacturers option when returned to Manufacturer, transportation prepaid.
   2. Motor Warranty is warranted by the motor manufacturer for a period of one year. Should motors furnished by us prove defective during this period, they should be returned to the nearest authorized motor service station.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:
   1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
   2. Operating Limits: Classify according to AMCA 99.

B. Balance Quality:
   1. All wheels (rotors/impellers) shall be factory statically and dynamically balanced on precision electronic balancers to a Balance Quality Grade G6.3 per ANSI/AMCA Standard 204-05 or better.

C. Vibration Levels:
   1. Each fan assembly shall be vibration tested before shipping in accordance with AMCA 204-05.
   2. Each assembled fan shall be test run at the factory at the specified fan RPM and vibration signatures shall be taken on each bearing in three planes - horizontal, vertical, and axial.
   3. Unless otherwise indicated, the maximum allowable factory fan vibration shall be less than 0.15 in./sec peak velocity for rigidly mounted fans and 0.20 in./sec peak velocity for flexibly mounted fans. Values are peak velocity values, filter-in, at the fan rotational speed.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Capacities and Characteristics: Refer to drawings.

2.02 DOWNBLAST, ROOF EXHAUST, CENTRIFUGAL FAN, DIRECT DRIVE (EF-1, EF-2)

A. Basis-of-Design Product: Subject to compliance with requirements, provide Greenheck G downblast centrifugal exhaust fan or comparable product by one of the following:
   1. American Coolair Corporation
   2. Greenheck Fan Corporation

3. Loren Cook Company
4. New York Blower Company (The)
5. Twin City Fan & Blower

B. General Description:
1. Factory-fabricated, -assembled, -tested, and -finished, direct-driven centrifugal downblast roof exhauster, configured for vertical flow, consisting of wheel, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Maximum continuous operating temperature is 180 Fahrenheit.
4. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number.

C. Wheel:
1. Constructed of aluminum.
2. Non-overloading, backward inclined centrifugal.
3. Statically and dynamically balanced in accordance to AMCA Standard 204-05.
4. The wheel cone and fan inlet shall be matched and shall have precise running tolerances for maximum performance and operating efficiency.

D. Electronically Commutated Motor:
1. Motor enclosures: Open drip type.
2. Motor shall be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
3. Motors shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
4. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor.
5. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor.
6. Motor shall be a minimum of 85% efficient at all speeds.

E. Housing:
1. Motor cover, shroud, curb cap, and lower windband shall be constructed of heavy gauge aluminum.
2. Shroud shall have an integral rolled bead for extra strength.
3. Shroud shall be drawn from a disc and direct air downward.
4. Lower windband shall have a formed edge for added strength.
5. Motor cover shall be drawn from a disc.
6. All housing components shall have final thicknesses equal to or greater than preformed thickness.
7. Curb cap shall have pre-punched mounting holes to ensure correct attachment.
8. Rigid internal support structure.
9. Leak proof.

F. Housing Supports and Drive Frame:
1. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.

G. Vibration Isolation:
1. Rubber isolators
2. Sized to match the weight of each fan.

H. Disconnect Switches:
1. NEMA Rated: 4.
2. Nonfusible type, with thermal-overload protection.
3. Wired from fan motor to junction box installed within motor compartment.

I. Curb Cap: One-piece, weather-tight aluminum construction, pre-punched mounting holes for attachment to roof curb. Include flange to mate with fan unit inlet flange.
   1. Provide electrical metal tubing (EMT) conduit into motor compartment, with watertight fitting at curb cap penetration.
   2. Provide foam curb seal.

J. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: Built-in cant and mounting flange.
   2. Overall Height: 12 inches.
   3. Pitch Mounting: Manufacture curb for roof slope, when required for level installation.

K. Accessories:
   1. Bird Screens: Removable, 1/2-inch mesh, aluminum wire.
   2. Hinged Subbase: Aluminum hinges and cables permitting service and maintenance.
   3. Motorized Damper: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan is not energized.
      a. Fabricate frame from galvanized steel.
      b. Fabricate blades from aluminum, mill finish, with vinyl edge seals.
      c. Damper actuator suitable for 24 VAC, single phase.
   4. Finish: None.
   5. Pressure Probe: ¼ inch diameter in the fan venturi that allows hook-up to manometer.
   6. Variable-Speed Controller:
      a. Factory programed, mounted and wired.
      b. Input speed control. potentiometer dial
      c. 24VDC damper power output
      d. 24VDC control power output
      e. Motor: (VFD Rated) compatible with induction and permanent magnet motors
      f. Parameters of acquainted motor shall be set to include voltage, speed, FLA, acceleration/deceleration time, and minimum & maximum motor frequency.
      g. R3 Filtering for harmonic mitigation
      h. UL Recognized for 3 phase input.
      i. NEMA 4X Enclosure
      j. LED indication for Power, Run, and Fault

2.03 SQUARE, IN-LINE, CENTRIFUGAL FAN, DIRECT DRIVEN (EF-3, EF-4)

A. Basis-of-Design Product: Subject to compliance with requirements, provide Greenheck SQ inline fan or comparable product by one of the following:
   1. American Coolair Corporation
   2. Greenheck Fan Corporation
   3. Loren Cook Company
   4. New York Blower Company (The)
   5. Twin City Fan & Blower

B. General Description:
   1. Factory-fabricated, -assembled, -tested, and -finished, direct-driven inline centrifugal fan, configured for horizontal flow, consisting of wheel, motor, drive assembly, and support structure.
   2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
   3. Maximum continuous operating temperature is 130 Fahrenheit.
   4. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number.

C. Wheel:
   1. Constructed of aluminum.
   2. Non-overloading, backward inclined centrifugal.
   3. Statically and dynamically balanced in accordance to AMCA Standard 204-05

4. The wheel cone and fan inlet shall be matched and shall have precise running tolerances for maximum performance and operating efficiency.
5. Single thickness blades shall be securely riveted or welded to a heavy gauge back plate and wheel cone.

D. Electronically Commutated Motor:
1. Motor enclosures: Open drip type.
2. Electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
3. Motors shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
4. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor or integrated variable frequency drive.
5. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
6. Motors shall achieve up to 95% efficiency, model and horsepower dependent..

E. Housing/Cabinet Construction:
1. Construction material: Aluminum
2. Square design constructed of heavy gauge aluminum.

F. Inlet Cone:
1. Construction material: Aluminum

G. Housing Supports and Drive Frame:
1. Drive Frame is constructed of structural steel with formed flanges.

H. Disconnect Switch:
1. NEMA Rated: 1.
2. Nonfusible type, with thermal-overload protection.
3. Wired from fan motor to junction box installed within motor compartment.

I. Duct Collar:
1. Square Duct Mounting Collar
   a. Inlet and discharge collars provide easy slip fit duct connection.
   b. Square design to provide a large discharge area.

J. Access Panel:
1. Two sided access panels, permit easy access to all internal components.
2. Located perpendicular to the motor mounting panel.

K. Accessories:
1. Motorized Damper: Parallel-blade damper with electric actuator; wired to close when fan is not energized.
   a. Galvanized frames with prepunched mounting holes
   b. Balanced for minimal resistance to flow.
   c. Damper actuator suitable for 24 VAC, single phase.
2. Finish: None.
3. Inlet and Outlet Guards:
   a. Metal construction to provide protection for non-ducted installations.
4. Insulated Housing
   a. Thickness: 1 inch.
   b. For noise reduction and condensation control.
   c. Constructed of nonfibrous liner.
5. Isolation:
   a. Type: Housed Spring
   b. Sized to match the weight of each fan
6. Motor Cover:

a. Constructed of galvanized steel
b. Covers motor and drives for safety
c. Standard on unit specified with UL and ODP motor enclosures

7. Pressure Probe: ¼ inch diameter in the fan venturi that allows hook-up to manometer.
8. Wiring Pigtail:
   a. Direct hook-up to the power supply
9. Variable-Speed Controller:
   a. Factory programed, mounted and wired
   b. Input speed control. potentiometer dial
   c. 24VDC damper power output
   d. 24VDC control power output
   e. Motor: (VFD Rated) compatible with induction and permanent magnet motors
   f. Parameters of acquainted motor shall be set to include voltage, speed, FLA, acceleration/deceleration time, and minimum & maximum motor frequency
   g. R3 Filtering for harmonic mitigation
   h. UL Recognized for 3 phase input
   i. NEMA 4X Enclosure
   j. LED indication for Power, Run, and Fault

2.04 HIGH PLUME LABORATORY EXHAUST FANS, DIRECT DRIVE (LEF-1, LEF-2, LEF-3, LEF-4)

A. Basis-of-Design Product: Subject to compliance with requirements, provide Greenheck Vektor-CH-ERS centrifugal backward-inclined scroll style exhaust fan with high plume discharge nozzle and energy recovery plenum or comparable product by one of the following:
   1. American Coolair Corporation
   2. Greenheck Fan Corporation
   3. Loren Cook Company
   4. New York Blower Company (The)
   5. Twin City Fan & Blower

B. General
   1. Base fan performance at standard.
   2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
   3. Each fan shall be direct driven in AMCA arrangement 8.
   4. Each fan to be equipped with 316 stainless steel lifting lugs for corrosion resistance.
   5. Fasteners exposed to corrosive exhaust shall be stainless steel.
   6. Fan assembly shall be designed for a minimum of 125 MPH wind loading, without the use of guy wires.

C. Corrosion Resistant Coating
   1. All steel fan and system components (fan, nozzle, windband and plenum) shall be corrosion resistant coated consisting of a two part electrostatically applied and baked, sustainable, corrosion resistant coating system. Standard finish color grey.
   2. All parts shall be cleaned and chemically prepared for coating using a multistage wash system which includes acid pickling to remove oxide, improving the coating bond to the substrate.
   3. The first powder coat applied over the prepared surface shall be an epoxy primer. After application, the coating shall be heated (partial cure) at which time the second powder coat of polyester resin shall be electrostatically applied and then be cured simultaneously at a uniform temperature of 400°F.
   4. The coating system shall not be less than a total thickness of 6 mils, shall not be affected by the UV component of sunlight (shall not chalk), and have superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 4000-hour ASTM B117 Salt Spray Resistance.

D. Fan Housing and Outlet
   1. Fan housing shall be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.

2. Fan housing shall be centrifugal involute scroll, allowing all drive components including the motor to be serviced without contact of the contaminated airstream, and manufactured of welded steel. Housing to be corrosion resistant coated per specification section 2.15.
    a. Fan housings that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, and / or which chalk and structurally degrade due to the UV component of the sunlight shall not be acceptable.
3. A high velocity discharge nozzle shall be supplied by the fan manufacturer designed to efficiently handle an outlet velocity of up to 7000 FPM. Discharge stack caps or hinged covers, impeding exhaust flow shall not be permitted.
4. An integral fan housing drain shall be used to drain rainwater when the fan is de-energized.
5. A bolted and gasketed access door shall be supplied in the fan housing allowing for servicing and cleaning. Access door can also be used for impeller inspection or removal of impeller, shaft and bearings without removal of the fan housing.
6. Fan assembly shall be AMCA Type B spark resistant construction minimum or as noted on the schedule.
7. Fan outlet shall terminate at 10’ above the roof line.

E. Fan Impeller
1. Fan impeller shall be centrifugal, single width, single inlet, backward inclined airfoil blade design with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically exceeding AMCA Standards.
2. Fan impeller shall be manufactured of welded and coated steel. Reference specification section 2.15 for corrosion resistant coating.
3. Fan impellers that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, and lower maximum tip speeds are not acceptable.

F. Pre-engineered Laboratory Air Plenum
1. The fan manufacturer shall provide an insulated, double wall, pre-engineered laboratory plenum, complete with heat recovery coil, external coil connections, side intake bypass damper, bolted coil access door and 2-inch MERV 8 pleated filters. The plenum shall be provided with bypass air damper(s) for introducing outside air at roof level upstream of the fan, complete with bypass air weatherhood and bird screen.
2. The plenum interior and exterior shall be constructed of welded galvanized steel and meet specification section 2.15 for corrosion resistant coating. Plenums that are fabricated of plastics or resins that are combustible and have mechanical properties less than steel shall not be acceptable.
3. The bypass air plenum shall be mounted on an insulated curb.
4. Bypass air damper(s) shall be opposed-blade design for airflow control, airfoil design, fabricated of galvanized steel for structural rigidity as standard. Bypass damper(s) shall have plated steel damper rods, stainless steel sleeved bearings, 301 stainless steel jamb seals and the blades shall have polymer edge seals. Damper model shall be equal to or exceed a heavy-duty control damper. Damper blade drive linkage shall be set by manufacturer and welded to eliminate linkage slippage. All damper access and service (drive actuators) shall be performed outside of the contaminated airstream.
5. An integral bypass air packed acoustic attenuator fabricated of galvanized steel shall be provided by the fan manufacturer.
6. Fan isolation damper(s) shall be parallel-blade design, airfoil design, fabricated of steel for structural rigidity as standard. Isolation damper(s) shall have plated steel damper rods, stainless steel sleeved bearings, 301 stainless steel jamb seals and the blades shall have polymer edge seals. Damper model shall be equal to or exceed a heavy-duty control damper. Damper blade drive linkage shall be set by manufacturer and welded to eliminate linkage slippage. All damper access and service (drive actuators) shall be performed outside of the contaminated airstream.
7. Isolation damper actuator(s) shall be furnished and field installed by the BAS provider.

8. Plenum shall include a removable bypass air weatherhood that is properly sized for low inlet velocity of the bypass air, minimizing the possibility of moisture entrainment.
9. Blower inlet shall be connected to the bypass air plenum utilizing a corrosion resistant UV inhibited flexible polymer boot, utilizing stainless steel straps, furnished by the fan manufacturer.

G. Bypass Air Plenum Curb
1. Exhaust system manufacturer shall supply a structural support curb for the plenum, of required height, as shown on the drawings.
2. Curb shall be fabricated of a minimum of 14 gauge of galvanized corrosion resistant coated steel and structurally reinforced.
3. Curbs shall be insulated.
4. Roof curb to be a minimum of 18 inches tall and include venting to prevent heat build-up around the duct.
5. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

H. Fan Motors and Drive
1. Motors shall be premium efficiency, standard NEMA frame, 1200, 1800 or 3600 RPM, TEFC with a 1.15 service factor and rated for variable frequency. A factory-mounted NEMA 4X disconnect switch shall be provided for each fan.
2. Motor maintenance shall be accomplished without fan or fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components.
3. Drive arrangement shall be AMCA arrangement 8, utilizing a direct mount coupling connecting the motor shaft and fan impeller shaft. Direct drive arrangement 4 requiring access and handling of hazardous and contaminated fan components for motor replacement is not acceptable.
4. Fan shaft to be turned and polished of 316 stainless steel as standard, coated with corrosion resistant coating.
5. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for a basic rating fatigue life (L-10) of 200,000 hours at maximum operating speed for each pressure class {Average life or (L-50) of 1,000,000 hours}. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be acceptable.
6. All shaft bearings and non-permanently lubricated motors shall have extended nylon lube lines with Zerk fittings.
7. Motor, coupling, and bearings shall all be outside the contaminated exhaust, and be capable of replacement without disassembling fan and accessing hazardous and contaminated fan components.
8. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

I. Airflow Monitoring and Electronics Package
1. Flow monitoring station shall monitor the pressure difference between the fan inlet and the smallest diameter of the inlet cone.
2. Volumetric flow shall be calculated from empirically derived formulas based on testing by the fan manufacturer.
3. Flow monitoring station shall not use air restricting flow devices that reduce fan performance or create additional fan sound.
4. Two (2) equidistantly spaced sensor orifices shall be drilled in the smallest diameter of the inlet cone venturi. Flow tubes from each venturi sensor shall be extended to a termination plate mounted on the fan housing.
5. High-pressure flow port(s) shall be mounted in low velocity fan inlet. Flow ports from the high-pressure sensor shall extend to a termination plate mounted on the fan housing.
6. Termination plate shall include a low-pressure connection, a high-pressure connection and a listing of the empirically determined flow rate coefficient.
7. Flow monitoring station shall accurately measure the pressure differential to within +/- 3%.

8. Flow monitoring station shall be installed by the fan manufacturer as part of the standard fan assembly.
9. Flow monitoring station shall be supplied with electronics package that includes pressure transmitter and LCD digital readout.
10. Material:
    a. Tubing: black polyethylene, UV resistant, chemically inert tubing, interior and exterior (standard), Temperature range: -100 - 175°F (-73 - 80°C)
    b. Tube Fittings: Stainless steel compression fittings, interior. Brass compression fittings, exterior
11. Interoperability using BACnet IP. The airflow monitoring station shall be remotely monitored and fully integrated with BAS software via BACnet IP communications protocol. Coordinate requirements with BAS provider.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans systems as indicated on the contract drawings and in accordance with manufacturer’s instructions.

B. Install power ventilators level and plumb.

C. Secure roof-mounted fans to roof curbs with cadmium-plated or stainless-steel hardware.

D. Ceiling units: suspend units from structure; use steel wire of metal straps.

E. Install units with clearances for service and maintenance.

F. Label units according to requirements specified.

G. High-Plume Laboratory Exhaust Fan
1. Fans shall be mounted on vibration isolators, furnished by the fan manufacturer, in accordance with those specified in specification section 1.4.C of this document.
2. Blower inlet shall be connected to the bypass air plenum utilizing a corrosion resistant UV inhibited flexible polymer boot, utilizing stainless steel straps, furnished by the fan manufacturer. Pipe housing drain to nearest drain.

3.02 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The total fan assembly after installation shall be checked for balance. Fans are to be statically and dynamically balanced to American National Standard Institute (ANSI) balancing tolerance of Grade G6.3 or as per AMCA Standard 204-96 - Balance Quality & Vibration Level for Fans.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Series fan-powered air terminal units.
   2. Shutoff, single-duct air terminal units.

B. Related Requirements:
   1. Section 23 09 00 "Building Automation System" for laboratory supply and exhaust air valves.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, mounting details and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, and location of each field connection (right or left).
   4. Include diagrams for power, signal, and control wiring.

B. Sustainability Submittals:
   1. Product Data: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

1.06 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

2.02 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 SERIES FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Anemostat Products; a Mestek Company.
   2. Carnes.
   3. Environmental Technologies, Inc.
   4. Krueger.
   5. METALAIRE, Inc.
   6. Nailor Industries Inc.
   7. Price Industries.
   8. Titus.
   9. Trane; a business of American Standard Companies.
   10. Tuttle & Bailey.

B. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling. Control cabinet and coil connections shall be on the same side to allow maintenance access through one ceiling tile.

C. Casing: 22 gauge (0.034-inch) galvanized steel, single wall.
   1. Casing Lining: Adhesive attached, 3/4-inch thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable bottom or side access panel, insulated, with airtight gasket and quarter-turn latches.
   5. Fan: Forward-curved centrifugal.
   6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
   7. All VAV boxes, if the interior insulation is exposed to the air stream, the insulation shall have an anti-microbial coating or foil faced insulation may be provided.

D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
   2. Damper Position: Normally open.

E. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.

F. Motor:
   1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
   2. Type: Electronically commutated motor.
   3. Fan-Motor Assembly Isolation: Rubber isolators.
   4. Enclosure: Open dripproof.
   5. Enclosure Materials: Rolled steel.
   6. Efficiency: Premium efficient.
   7. NEMA Design: 1
   8. Motor Speed: Variable speed
      a. Speed Control: Infinitely adjustable with electronic controls.

9. Electrical Characteristics: See schedule on drawings.

G. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Material: Pleated cotton-polyester media having 90 percent arrestance and 8 MERV.
   2. Thickness: 1 inch

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Direct Digital Controls: Factory installed controls furnished under Division 23, Section “Building Automation Systems”.
   1. The terminals shall be equipped with pressure independent controls which can be reset to modulate airflow between zero and the maximum cataloged cubic feet per minute. Maximum airflow limiters are not acceptable.
   2. The direct digital controls shall be supplied by the control contractor and mounted by the terminal unit manufacturer. Control contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings, to the terminal manufacturer.
   3. Controls shall be compatible with pneumatic inlet velocity sensors supplied by the terminal manufacturer. The sensor shall be multi-point center averaging type, with a minimum of four measuring ports parallel to the take-off point from the sensor. Sensors with measuring ports in series are not acceptable. The sensor must provide a minimum differential pressure signal of 0.03 inch wg. at an inlet velocity of 500 fpm. The sensor must provide control signal accuracy of plus or minus five (5) percent with the same size inlet duct at any inlet condition.
   4. Controls shall be field set by control contractor for the scheduled minimum and maximum flow rates. Flow measuring taps and flow curves will be supplied with each terminal for field balancing airflow. All pneumatic tubing shall be UL listed fire retardant (FR) type. Each terminal shall be equipped with labeling showing unit location, size, minimum and maximum cubic feet per minute setpoints, damper fail position, and thermostat action.
   5. The terminal manufacturer shall provide a Class II 24 VAC transformer and disconnect switch. Actuator shall be direct connection shaft mount type without linkage. All controls shall be installed in approved NEMA type sheet metal enclosure by terminal manufacturer.
   6. Box controllers with self calibration shall not interrupt flow.

2.04 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Anemostat Products; a Mestek Company.
   2. Carnes.
   3. Environmental Technologies, Inc.
   4. Krueger.
   5. METALAIRE, Inc.
   6. Nailor Industries Inc.
   7. Phoenix Controls Corporation.
   8. Price Industries.
   9. Titus.
   10. Trane; a business of American Standard Companies.
   11. Trox USA Inc.; a subsidiary of the TROX GROUP.
   12. Tuttle & Bailey.
   13. Warren Technology.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud. Control cabinet and coil connections shall be on the same side to allow maintenance access through one ceiling tile.

C. Casing: 0.034-inch steel double wall.
   1. Casing Lining: Adhesive attached, 3/4-inch thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections, size matching inlet size.
   4. Access: Removable bottom or side access panel, insulated, with airtight gasket and quarter-turn latches.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
   2. Damper Position: Normally open.

F. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

G. Direct Digital Controls: Factory installed controls furnished under Division 23, Section “Building Automation Systems”.
   1. The terminals shall be equipped with pressure independent controls which can be reset to modulate airflow between zero and the maximum cataloged cubic feet per minute. Maximum airflow limiters are not acceptable.
   2. The direct digital controls shall be supplied by the control contractor and mounted by the terminal unit manufacturer. Control contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings, to the terminal manufacturer.
   3. Controls shall be compatible with pneumatic inlet velocity sensors supplied by the terminal manufacturer. The sensor shall be multi-point center averaging type, with a minimum of four measuring ports parallel to the take-off point from the sensor. Sensors with measuring ports in series are not acceptable. The sensor must provide a minimum differential pressure signal of 0.03 inch wg. at an inlet velocity of 500 fpm. The sensor must provide control signal accuracy of plus or minus five (5) percent with the same size inlet duct at any inlet condition.
   4. Controls shall be field set by control contractor for the scheduled minimum and maximum flow rates. Flow measuring taps and flow curves will be supplied with each terminal for field balancing airflow. All pneumatic tubing shall be UL listed fire retardant (FR) type. Each terminal shall be equipped with labeling showing unit location, size, minimum and maximum cubic feet per minute setpoints, damper fail position, and thermostat action.
   5. The terminal manufacturer shall provide a Class II 24 VAC transformer and disconnect switch. Actuator shall be direct connection shaft mount type without linkage. All controls shall be installed in approved NEMA type sheet metal enclosure by terminal manufacturer.
   6. Box controllers with self calibration shall not interrupt flow.

2.05 EXHAUST SINGLE-DUCT TERMINAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Anemostat Products; a Mestek company
   2. Carnes Company
   3. Carrier Corporation; a unit of United Technologies Corp.

4. ENVIRO-TEC; by Johnson Controls, Inc
5. Johnson Controls
6. Krueger
7. METALAIRE, Inc
8. Nailor Industries Inc
9. Price Industries
10. Titus
11. Trane
12. Tuttle & Bailey

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
   1. Terminal unit shall be a unit specifically manufactured for exhaust airflow with rectangular inlet and outlets, and not a supply terminal unit installed backwards with relocated airflow sensors.

C. Casing: 22 gauge (0.034-inch) galvanized steel, single wall.
   1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
   2. Air Inlet: S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections for duct attachment,
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: 16 gauge (0.064-inch) thick galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
   2. Damper Position: Normally open.

E. Attenuator Section: 22 gauge (0.034-inch) steel sheet.
   1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Direct Digital Controls: Factory installed controls furnished under Division 23, Section “Building Automation Systems”
   1. The terminals shall be equipped with pressure independent controls which can be reset to modulate airflow between zero and the maximum cataloged cubic feet per minute. Maximum airflow limiters are not acceptable.
   2. The direct digital controls shall be supplied by the control contractor and mounted by the terminal unit manufacturer. Control contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings, to the terminal manufacturer.
   3. Controls shall be compatible with pneumatic inlet velocity sensors supplied by the terminal manufacturer. The sensor shall be multi-point center averaging type, with a minimum of four measuring ports parallel to the take-off point from the sensor. Sensors with measuring ports in series are not acceptable. The sensor must provide a minimum differential pressure signal of 0.03 inch wg. at an inlet velocity of 500 fpm. The sensor must provide control signal accuracy of plus or minus five (5) percent with the same size inlet duct at any inlet condition.
   4. Controls shall be field set by control contractor for the scheduled minimum and maximum flow rates. Flow measuring taps and flow curves will be supplied with each terminal for field balancing airflow. All pneumatic tubing shall be UL listed fire retardant (FR) type.

Each terminal shall be equipped with labeling showing unit location, size, minimum and maximum cubic feet per minute setpoints and damper fail position.

5. The terminal manufacturer shall provide a Class II 24 VAC transformer and disconnect switch. Actuator shall be direct connection shaft mount type without linkage. All controls shall be installed in approved NEMA type sheet metal enclosure by terminal manufacturer.
6. Box controllers with self calibration shall not interrupt flow.

2.06 CASING LINER

A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
   1. Minimum Thickness: 3/4 inch.
   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A.

2.07 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.
   1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Provide access doors on both the upstream and downstream side of the heating coil. The access doors shall be insulated to prevent condensation.

D. Clearances around VAV boxes, reheat coils shall be sufficient to allow inspection, service, repair or replacement without removing elements of permanent construction and in accordance with the manufacturers recommended clearances. Coordinate with all other trades to protect the service area around equipment. In office areas, VAV boxes are not to be placed directly over a fixed podium, desk or table or over/adjacent to a light fixture. Do not locate VAV boxes adjacent to interior partitions or exterior walls without providing the manufacturers recommended clearances.

E. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm’s length.

3.02 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.03 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 Hydronic Piping Specialties," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to Section 23 31 13 "Metal Ducts."

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 23 33 00 "Air Duct Accessories."

3.04 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Registers, grilles and diffusers.
   2. Fan filter units.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers with factory-applied color finishes.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 AIR DEVICES, GENERAL

A. Basis-of-Design Product: Subject to compliance with requirements, provide Price or comparable product by one of the following:
   1. Anemostat Products; a Mestek company
   2. Carnes Company
   3. Krueger
   4. METALAIRE, Inc
   5. Nailor Industries Inc
   6. Price Industries
   7. Titus
   8. Tuttle & Bailey

B. Provide air devices of the minimum sizes and quantities indicated and of the types specified.

C. Contractor shall carefully study the drawings and the field conditions to ascertain the air device requirements as to suitability, location, air capacity, required accessories, border and finish.

D. Border types shall be compatible with Architectural ceiling type for the room for which the air device is located. All devices shall have plaster frames when installed in plaster or drywall construction.

E. Margins shall be as indicated or directed to suit field conditions.

F. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

G. Air devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed Noise Criteria (NC) 25.

H. Air device finish for all components shall be a baked-on powder coat finish.
   1. The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
   2. The paint film thickness shall be a minimum of 2.0 mils.
   3. The finish shall have a pencil hardness of 2H.
   4. The finish shall withstand a minimum salt spray exposure of 500 hours with no measurable creep in accordance with ASTM D1654, and 1000 hours of exposure with no rusting or blistering as per ASTM D610 and ASTM D714.
   5. The finish shall have an impact resistance of 50 inch-pounds.

2.02 TYPE A: SQUARE CONE DIFFUSER, ALUMINUM

A. Square cone ceiling diffusers shall be Price Model ASCD (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Diffusers shall be aluminum construction, and shall consist of a seamless, one-piece, precision formed backpan that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.

C. The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.

D. An inner cone assembly shall consist of 3 or 4 cones which drop below the ceiling plane to assure optimal VAV air diffusion performance. The inner cone assembly shall be completely removable from the diffuser face to allow for full access to any dampers or other ductwork components located near the diffuser neck.

E. Opposed blade volume damper shall not be provided.

F. Molded insulation blanket for the diffuser back pan shall be available. The insulation shall be R-6, foil-backed, and provide an additional 1-inch gap around the neck to install insulated flex duct.

G. The grille finish shall be B12 standard white.

2.03 TYPE B: SQUARE CONE DIFFUSER, ALUMINUM

A. Square cone ceiling diffusers shall be Price Model ASCD (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Diffusers shall be aluminum construction, and shall consist of a seamless, one-piece, precision formed backpan that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.

C. The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.

D. An inner cone assembly shall consist of 3 or 4 cones which drop below the ceiling plane to assure optimal VAV air diffusion performance. The inner cone assembly shall be completely removable from the diffuser face to allow for full access to any dampers or other ductwork components located near the diffuser neck.

E. Opposed blade volume damper shall not be provided.

F. Include square to round neck adaptor.

G. Molded insulation blanket for the diffuser back pan shall be available. The insulation shall be R-6, foil-backed, and provide an additional 1-inch gap around the neck to install insulated flex duct.

H. The grille finish shall be standard white.

2.04 TYPE C AND C1: LINEAR SLOT DIFFUSER, ALUMINUM

A. Modulinear slot diffusers shall be Price Model SDS slot (supply) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Provide drawings accompanied by an itemized list indicating the unit locations and appropriate product submittal drawings provided by the manufacturer. Exact dimensions of the walls and ceiling are per the architectural drawings.

C. The diffusers shall have 1 to 4 discharge slots (as scheduled) with 1 inch slot width.

D. The supply diffusers shall have aerodynamically curved “ice-tong” shaped pattern controllers for 180-degree air pattern control and airflow dampering.

E. The diffuser border shall be extruded aluminum construction with extruded aluminum spacers and mitered end flanges, flush end caps, or flange end caps to close off the ends of the diffusers.

F. Continuous length units shall be provided with factory assembled corner modules to suit drawings and site conditions. Splice plates and alignment plates shall be provided to align continuous slot assemblies. The maximum section length shall be 72 inches.

G. The linear slot diffusers shall be compatible for surface or T-bar lay in mounting:

H. Mitered Corners: Where required, the diffuser shall be supplied with inactive [mitered corner assemblies. The mitered corners shall be extruded aluminum construction, with an all welded, factory assembled miter, finished to match the associated straight sections of the slot diffuser.

I. Blank off: Where required, the diffuser shall be supplied with metal blank off sections. The blank-offs shall cover inactive sections of the slot diffuser and shall be shipped loose for field cutting and installation.

J. Alignment Strips: The diffuser shall include alignment strips when the diffuser is supplied in multiple sections to provide linear alignment to the continuous slot diffuser.

K. Plaster Frame Spacers: The diffuser shall be supplied with plaster frame spacers to provide the correct spacing of the plaster frame prior to installation of the diffuser.

L. Field Cut Diffusers: Where a continuous run of diffuser is required, the diffuser shall be supplied six inches longer than specified to allow the diffuser to be cut to size in the field.

M. Equalizing Core: The diffuser shall be supplied with an equalizing core to equalize the air velocity over the face of the diffuser.

N. Plenums: Externally insulated plenums shall be manufactured by the same manufacturer of the linear slot diffusers.

O. The finish shall be standard white on the face and black on the pattern controllers.

P. Linear fixtures in the main lobby shall be continuous for visual effect, even though some devices will not be ducted. Refer to the notes on the plans.

Q. Type C1 shall have custom plenum with end inlet.

2.05 TYPE D: LOUVERED SUPPLY GRILLE, ALUMINUM

A. Aluminum louvered supply grille shall be Price Model 620 (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Grilles shall be double deflection louver type, and shall have two sets of fully adjustable blades, with the second set behind the first set, and with 3/4 inch on center blade spacing.

C. The grilles front blade orientation shall be front blades parallel to the long dimension.

D. The blades and border shall be aluminum construction.

E. Opposed blade volume damper shall not be provided.

F. The grille finish shall be standard white.

2.06 TYPE E: LAMINAR FLOW DIFFUSER, ALUMINUM

A. Aluminum laminar flow diffusers shall be Price Model LFD (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. The laminar flow diffusers shall be non-aspirating, unidirectional type, providing a uniform vertical projection of air at controlled low velocities and minimal entrainment of room air, satisfying the requirements of ASHRAE Standard 170.

C. Face and frame material shall be aluminum. Plenum shall be continuously welded aluminum.

D. The plenum shall be divided into an upper and lower chamber utilizing an internal pressure equalization baffle to promote uniform face velocity.

E. Air shall be admitted to the top plenum chamber through an inlet collar.

F. The diffuser plenum shall feature four (4) integral hanger tabs for securing the unit to structural supports above the ceiling.

G. Mounting frames shall utilize corner alignment brackets.

H. The 13% free-area perforated distribution plate shall be secured to the face using stainless steel quarter-turn fasteners with anti-slip, snap-in retainers and stainless-steel retainer cables for ease of installation and removal.

I. The diffuser plenum shall be externally insulated with 1-1/2” aluminum foil-backed fiberglass insulation.
   1. Insulation shall not contain formaldehyde.
   2. Insulation and adhesive surface burning characteristics shall have a maximum flame/smoke spread of 25/50 when tested in accordance with ASTM E84. Secure insulation with adhesive. Coat edges exposed to airstream with NFPA 90A approved sealant.
   3. Insulation shall meet the requirements of ASTM-84 and UL 723.

J. The diffuser face and inlet shall be covered with a protective film, to be removed at the time of installation.

K. Opposed blade volume damper shall not be provided.

L. The plenum and face and frame finish shall be standard white.

2.07 TYPE F: AIRFOIL SUPPLY GRILLE, ALUMINUM

A. Single deflection airfoil supply grille shall be Price Model 20 (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. The grille material shall be aluminum with precision mitered corners.

C. The adjustable airfoil blades shall be secured in place by a stainless-steel tensioning wire.

D. The grilles front blade orientation shall be parallel to the long dimension.

E. The single deflection cores shall have one set of blades with ¾ inch on center blade spacing.

F. The grille shall be supplied with a mullion when nominal grille dimensions exceed 20 inches.

G. Opposed blade volume damper shall not be provided.

H. The grille finish shall be standard white.

2.08 TYPE G: PERFORATED RETURN DIFFUSER, ALUMINUM

A. Perforated return diffuser shall be Price Model APDDR (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. The return diffuser shall consist of a perforated air distribution face of no less than 51 percent free area, a heavy gauge steel back pan with round or square inlet collars as noted on the plans.

C. The perforated face screen construction shall be aluminum.

D. The perforated face shall be removable from the diffuser face and shall be hinged for ease of removal of the face screen for cleaning purposes.

E. For plenum return, non-ducted applications, the return diffuser shall be provided with a special frame assembly to maximize free area.

F. Opposed blade volume damper shall not be provided.

G. The grille finish shall be standard white.

2.09 TYPE H: PERFORATED RETURN DIFFUSER, ALUMINUM

A. Perforated return diffuser shall be Price Model APDDR (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. The return diffuser shall consist of a perforated air distribution face of no less than 51 percent free area, a heavy gauge steel back pan with round or square inlet collars as noted on the plans.

C. The perforated face screen construction shall be aluminum.

D. The perforated face shall be removable from the diffuser face and shall be hinged for ease of removal of the face screen for cleaning purposes.

E. For plenum return, non-ducted applications, the return diffuser shall be provided with a special frame assembly to maximize free area.

F. Opposed blade volume damper shall not be provided.

G. The grille finish shall be standard white.

2.10 TYPE I: LINEAR BAR GRILLE, ALUMINUM

A. Linear bar grille shall be Price Model LBP (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Grille shall have fixed 30-degree deflection blades spaced 1/2 inch on center. The blades shall run parallel to the long dimension of the grille.

C. Grille blades, border, and mullions material shall be heavy extruded aluminum construction.

D. Units wider than 18 inches shall be supplied in multiple sections with mounting channels. The maximum section length shall be 72 inches.

E. Core shall be supplied with 3/16-inch bars.

F. Grille shall be supplied with both ends mitered.

G. Opposed blade volume damper shall not be provided.

H. The grille finish shall be standard white.

2.11 TYPE J: LOUVERED RETURN GRILLE, ALUMINUM

A. Louvered return grille shall be Price Model 630 (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Grilles shall be single 45-degree deflection fixed louver type and shall have one set of blades with 3/4 inch on center blade spacing.

C. The grilles front blade orientation shall be front blades parallel to the long dimension.

D. The blades and border shall be extruded aluminum construction.

E. Opposed blade volume damper shall not be provided.

F. The grille finish shall be standard white.

2.12 TYPE K: PERFORATED EXHAUST DIFFUSER, ALUMINUM

A. Perforated exhaust diffuser shall be Price Model APDDR (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. The exhaust diffuser shall consist of a perforated air distribution face of no less than 51 percent free area, a heavy gauge steel back pan with round or square inlet collars as noted on the plans.

C. The perforated face screen construction shall be aluminum.

D. The perforated face shall be removable from the diffuser face and shall be hinged for ease of removal of the face screen for cleaning purposes.

E. Opposed blade volume damper shall not be provided.

F. The grille finish shall be standard white.

2.13 TYPE L: PERFORATED EXHAUST DIFFUSER, ALUMINUM

A. Perforated exhaust diffuser shall be Price Model APDDR (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. The exhaust diffuser shall consist of a perforated air distribution face of no less than 51 percent free area, a heavy gauge steel back pan with round or square inlet collars as noted on the plans.

C. The perforated face screen construction shall be aluminum.

D. The perforated face shall be removable from the diffuser face and shall be hinged for ease of removal of the face screen for cleaning purposes.

E. Opposed blade volume damper shall not be provided.

F. The grille finish shall be standard white.

2.14 TYPE M: LOUVERED EXHAUST GRILLE, ALUMINUM

A. Louvered exhaust grille shall be Price Model 630 (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Grilles shall be single 45-degree deflection fixed louver type and shall have one set of blades with 3/4 inch on center blade spacing.

C. The grilles front blade orientation shall be front blades parallel to the long dimension.

D. The blades and border shall be extruded aluminum construction.

E. Opposed blade volume damper shall not be provided.

F. The grille finish shall be standard white.

2.15 TYPE N: LOUVERED FILTERED EXHAUST GRILLE, ALUMINUM

A. Louvered filtered exhaust grille shall be Price Model 630FF (aluminum) or approved equal of sizes and mounting types designated by the plans and air distribution schedule.

B. Grille shall be 45-degree deflection fixed louver type to minimize see-through and shall have one set of blades with 3/4 inch on center blade spacing.

C. Grille front blade orientation shall be front blades parallel to the long dimension.

D. Blades and border shall be heavy extruded aluminum construction.

E. Grille shall use a hinge and quarter turn quick-release fasteners for access.

F. Grille shall be supplied with a 3/8-inch flat border mounting frame. A hinge-tab mechanism shall allow hinging or removal of the grille from the filter frame for cleaning. Hinge tab orientation shall be parallel to the long dimension.

G. The filter frame shall accept 1-inch MERV-8 filter media, supplied by mechanical contractor.

H. Filter shall be medium efficiency ASHRAE pleated panels consisting of synthetic blend media, welded wire media support grid, and beverage board enclosing frame equal to Camfil Far 30/30.

I. Opposed blade volume damper shall not be provided.

J. The grille finish shall be standard white.

2.16 FAN FILTER UNIT:

A. Basis of Design: Price Industries, Inc.
   1. Fan Filter Unit: Model FFU RSR

B. General:
   1. The fan filter unit shall be supplied to provide unidirectional supply air at controlled discharge velocities. The units shall include a high efficiency HEPA.
   2. Modules sizes, electrical characteristics, efficiencies, capacities, and options shall be as scheduled on the drawings.

C. Fan Filter Unit:
   1. Performance:
      a. The unit shall provide filtered air tested at an average velocity of 90 fpm (+/- 15 fpm) measured 12 inches from the face of the unit in accordance with IEST-RP-CC0022.2.
      b. The room sound level shall be less than 55 dBA when measured at 30 inches from the filter face at 90 fpm average face velocity in accordance with IEST-RP-CC0022.2.
      c. The unit is to be factory sealed and tested to assure leakage is consistent with the filter.
   2. Construction:
      a. Plenum material shall be:
         1) Aluminum
      b. Face material shall be:
         1) 304 stainless steel
      c. Plenum shall be walkable up to 250 lbs.
      d. The diffuser plenum shall feature four (4) eyebolts at each plenum corner for securing the unit to structural supports above the ceiling.
      e. The 51% free-area perforated distribution plate shall be secured to the face using quarter-turn fasteners with anti-slip, snap-in retainers and stainless-steel retainer cables for ease of installation and removal.
      f. Inlet: standard round collar.
      g. Eye bolts for hanging shall be mounted on the top four (4) corners of the plenum and capable of each supporting 75 lbs.
   3. Filters:
      a. The filter shall be framed in extruded aluminum with an integral cavity filled with a urethane gel to provide a leak-tight seal between the filter frame and the border.
      b. Filter type shall be:
         1) High Efficiency Particulate Air (HEPA) filter shall provide 99.997% efficiency on .30 µm particulate, with an initial pressure drop of 0.45” wg at 100 fpm.
      c. Filter shall be UL 900 classified.
      d. Filter pack depth shall be 2.5”.
      e. Filter media shall be borosilicate micro-fiberglass.
      f. Filter shall be:
         1) Room side removable and replaceable, mounted in an extruded aluminum frame and provided with a gel seal knife edge.
   4. Plenum Finish shall be:
      a. All aluminum components shall have standard white baked-on powder coat finish.
         1) The paint finish must demonstrate no degradation when tested in accordance with ASTM D1308 (covered and spot immersion) and ASTM D4752 (MEK double rub) paint durability tests.
         2) The paint film thickness shall be a minimum of 2.0 mils.
         3) The finish shall have a hardness of 2H.
         4) The finish shall withstand a minimum salt spray exposure of 1000 hours.
         5) The finish shall have an impact resistance of 80 in-lb.
   5. Face and frame finish shall be:
      a. All stainless-steel components shall have #4 polished finish on all exposed surfaces.
   6. Fan:

a. The centrifugal type fan shall be supplied with rubber mounts to isolate the motor/blower assembly from the diffuser plenum.
b. Fans are to be of metal construction with a direct drive:
    1) Forward curved impeller
c. Plastic construction shall not be acceptable.

7. Electrical Systems:
    a. Single point power connection.
    b. Transformers shall be included where required for motor and unit operation.
8. Fan Motor:
    a. The fan motor shall be:
        1) Electrically Commutated Motor (ECM):
            a) Constant Flow Program
            b) A constant flow program shall be provided to allow the ECM to compensate for fluctuations in both upstream static pressure and filter pressure drop, providing constant airflow.
            c) The constant flow program shall be used for non-ducted applications where the inlet static pressure is zero or slightly negative.
    b. Fan motor shaft directly connected to fan and isolated from casing to prevent transmission of vibration.
    c. Fan motor shall have internal thermal and overload protection.
    d. Fan motor shaft shall be directly connected to the fan impeller, and isolated from casing to prevent transmission of vibration.
    e. Fan motor shall be supplied with a motor speed controller:
        1) ECM standard speed controller
            a) The ECM speed controller shall operate on 24 VAC supply voltage.
            b) The ECM speed controller shall have dual outputs to control up to two motors simultaneously.
            c) The ECM speed controller shall be supplied with a BAS interface to accept 2-10 VDC signal for variable speed remote control, as well as be able to remotely shut off via BAS signal.
            d) The ECM speed controller shall be supplied as a wall mounted kit, shipped loose for field installation.
9. Accessories:
    a. Filter replacement style:
        1) Room Side replaceable filter
    b. Pre-filter:
        1) Unit shall be provided with 25-30% MERV 4 washable pre-filter with side access filter housing.
    c. Disconnect Switch: A factory supplied disconnect switch shall be provided for disconnection of power to the terminal block.
    d. Power cord:
        1) An eight-foot power cord shall be supplied for use with a 115 V power supply.
    e. Motor/blower access
        1) Room side access
    f. Wall-mounted ECM standard speed controller:
        1) The ECM speed controller shall be capable of daisy chain connections to connect and control eight fan filter units simultaneously.
    g. Filter status indicator shall be communicated by:
        1) BAS Signal:
            a) The filter BAS signal shall close a dry contact to generate a BAS signal when the static pressure is greater than the specified limit.
            b) The BAS signal is factory- calibrated for 150% of initial clean filter pressure drop.
            c) Unit shall be field wired to the terminal block according to manufacturer’s instructions.

h. Motor status shall be communicated by:
   1) Motor status LED:
      a) The LED indicator light shall be visible from the occupied area to determine the motor operating status without opening the diffuser.
      b) The motor LED shall be green to indicate normal motor operation, and that the unit static pressure is above 0.2” wg.
      c) The motor LED shall turn from green to red when the motor is not in operation, and when the unit static pressure is below 0.2” wg.

i. Motor status BAS signal:
   1) The factory- calibrated motor BAS signal shall close a dry contact to generate a BAS signal when the motor is not operating.
      a) Unit shall be field wired to the terminal block according to manufacturer’s instructions.

j. BACnet Flow Controller:
   1) The BACnet Flow Controller shall be supplied to facilitate adjustment or monitoring of the following parameters through the building networks:
      a) Airflow rate
      b) Motor rpm
      c) Motor hours
      d) Filter status
      e) Filter pressure drop displayed in inches of water
      f) Filter hours
      g) Filter reset

k. Aerosol test system:
   1) A room-side accessible aerosol test system shall be provided for injecting aerosol challenge into the diffuser to allow the filter to be scanned for leaks during commissioning or after filter replacement.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers, registers, grilles and fan filter units are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Air devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed the Noise Criteria (NC) indicated on the air device schedule.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

E. All devices shall have plaster frames when installed in plaster or drywall construction. Margins shall be as indicated or directed to suit field conditions.

F. Align exposed butt edges of linear diffusers using slots and keys or with other concealed means.

G. Paint the ductwork behind registers with flat black enamel so that bright surface cannot be seen. Properly prime galvanized surface prior to painting.

H. Fan filter units shall be supported individually from the structure in accordance with SMACNA (SRM).

3.03 ADJUSTING

A. After installation, adjust diffusers, registers, grilles, and fan filter units to air patterns indicated, or as directed, before starting air balancing.

B. The position of the pattern controllers for linear supply diffusers shall be verified and adjusted during Testing, Adjusting and Balancing.

C. Ensure supply air to the fan filter units by performing pilot transverse of the main supply duct.

END OF SECTION

SECTION 23 41 00 - PARTICULATE AIR FILTRATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Pleated panel filters.
   2. Rigid cell box filters.
   3. Front- and rear-access filter frames.
   4. Side-service housings.
   5. Filter gages.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
   1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
   2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
   3. Include diagram for power, signal, and control wiring.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.04 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: For each filter bank, provide:
      a. One complete set of filters at the start of testing, adjusting and balancing (TAB).
      b. One complete set of filters for final turnover to owner.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:
   1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
   2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
   3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Comply with NFPA 90A and NFPA 90B.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 PLEATED PANEL FILTERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr 30/30 or comparable product by one of the following:
   1. 3M
   2. AAF International
   3. Airguard

4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

C. Filter Unit Class: UL 900, Class 2.

D. Media: Cotton and synthetic fibers coated with nonflammable adhesive.
1. Media shall be coated with an antimicrobial agent.
2. Separators shall be bonded to the media to maintain pleat configuration.
3. Welded-wire grid shall be on downstream side to maintain pleat.
4. Media shall be bonded to frame to prevent air bypass.
5. Support members on upstream and downstream sides to maintain pleat spacing.

E. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

F. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

G. Capacities and Characteristics:
1. Capacities, efficiencies, and size of filter units shall be as scheduled on the drawings.
2. Maximum or Rated Face Velocity: 450 fpm.
3. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
4. MERV Rating: 8 when tested according to ASHRAE 52.2.
5. Recommended Final Resistance: 1.0” inches wg at 500 fpm.

2.03 RIGID CELL BOX FILTERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Riga-Flo or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Description: Factory-fabricated, self-supported, extended-surface, high efficiency media box filter with media perpendicular to airflow, and with holding frames.

C. Filter Unit Class: UL 900, Class 2.

D. Media: Microfine glass media in a uniform high loft blanket.
1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.
3. The media blanket shall be formed into uniform tapered radial pleats and bonded to a stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.
4. The media shall be mechanically and chemically bonded within the frame to prevent air bypass.

E. Filter-Media Frame: Corrosion resistant galvanized steel sealed or bonded to the media.

F. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

G. Capacities and Characteristics:
1. Capacities, efficiencies, and size of filter units shall be as scheduled on the drawings.
2. Maximum or Rated Face Velocity: 450 fpm.

3. MERV Rating: 13 when tested according to ASHRAE 52.2.
4. Recommended Final Resistance: 1.5” inches wg at 500 fpm.

2.04 FRONT- AND REAR-ACCESS FILTER FRAMES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Type 8 or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Framing System: Galvanized-steel framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

C. Prefilters: Incorporate a separate track with spring clips, removable from front.

D. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

E. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.

2.05 SIDE-SERVICE HOUSINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Type 3P Glide/Pack or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Description: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct or casing system.

C. Prefilters: Where indicated to be installed with prefilters, frame shall incorporate the capability of two stages of filtration with integral tracks to accommodate 2-inch- deep, disposable prefilters.

D. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.

E. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

F. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.

G. Accessories:
1. Filter removal rod.

2.06 FILTER GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AirGuard; Clarcor Air Filtration Products, Inc.
2. Dwyer Instruments, Inc.

B. Magnehelic diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Diameter: 4-1/2 inches.
   2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.
   3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.
   4. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg or Less: 0- to 2.0-inch wg.
   5. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg or Less: 0- to 3.0-inch wg.
   6. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg or Less: 0- to 4.0-inch wg.

C. Accessories: Two 1/8” NPT plugs for duplicate pressure taps, tubing, gage connections, and mounting bracket.

PART 3 EXECUTION

3.01 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test for leakage of unfiltered air while system is operating.

B. Air filter will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.03 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION

SECTION 23 43 00 – ELECTRONIC AIR CLEANERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Modular needlepoint bipolar ionization system.

B. Related Requirements:
   1. Section 23 09 00 "Building Automation System" and drawings for ionization system interface to the building automation system.
   2. Section 23 73 13 "Modular Air Handling Units" for housings used for electronic air cleaners.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For each electronic air cleaner.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.03 QUALITY ASSURANCE

A. The pollutant reduction bipolar ionization system shall be a product of an established manufacturer with a minimum of five (5) years of continuous operation in the USA.

B. Air cleaner shall be certified in accordance with UL 867 and UL 2998 as ozone-free. The documentation must comply with the current 2016 UL Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions. The product, at the highest setting, shall undergo Ozone Test as described by UL 867 Section 40. Test report required.

1.04 COORDINATION

A. Coordinate size, location and installation of air cleaners with air-handling units to suit conditions and to ensure proper operation.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Unit shall have demonstrated in tests conducted by an independent test laboratory a statistically significant capability to substantially reduce gas phase contaminants generated from human occupants, common VOCs and airborne viruses and bacteria in the conditioned space. Gases for which statistically significant control shall be demonstrated are formaldehyde (CH20), ammonia (NH3), sulphur dioxide (S02), carbon dioxide (CO2), SARS-CoV-2, Influenza, RSV, MRSA, and E.coli.

B. ASHRAE Compliance:
   1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Equipment shall be capable of performing in non-condensing atmospheres at temperatures up to 140°F.

2.02 ELECTRONIC AIR CLEANERS

A. Description: Factory-fabricated, modular electronic air cleaner operating by needlepoint bipolar ionization principles for installation in an air handling system.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Global Plasma Solutions GPS-iMOD or comparable product by one of the following:
      a. AtmosAir Solutions
      b. Global Plasma Solutions
      c. Plasma Air International

B. System shall include the power unit module, power cable, required number of modular sections to achieve desired bar length and coverage, end cap(s), mounting magnets and accessory items.

C. Construction: Corrosion proof. Composite and carbon fiber.

D. Performance:
   1. Output Voltage: 5 kV RMS
   2. Output Frequency: 60 Hz
   3. Output Current: 3mA
   4. Total Ion Output: >140M ions/cc per inch of bar
   5. Temperature Range: –20° F to 140° F
   6. Humidity Range: 0–100% RH

E. Electrical:
   1. Input Voltage: 120 VAC
   2. Input Frequency: 60 Hz
   3. Input Amps: 0.13A
   4. Power Consumption: 15W

F. Accessories:
   1. NEMA 4x-rated fiberglass enclosure designed to house power supply, with illuminated on/off switch, power on, system off, LED indicators.
   2. Duct mounted ion detector to be permanently mounted in duct downstream of air-handling unit, capable of measuring 20,000 to 2 Million Ions/cc in real time and shall report levels back to the BAS.
   3. Air flow switch.
   4. Door switch.

G. Controls:
   1. Unit shall have internal ionization output sensing, with integral alarm contacts for operation and alarm notification.
   2. Ionization system shall be connected to the BAS system for status monitoring and control. Coordinate requirements with BAS provider. Building automation system is specified in Section 23 09 00 "Building Automation System."
   3. All control functions shall be capable of being provided remotely at the BAS through the network connection.
   4. Airflow switch, door switch, ion detector and control relays shall be included as part of the ionization equipment scope.

H. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine electronic air cleaners and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Mechanical and electrical installation procedures and materials shall be in accordance with the manufacturer’s instructions, submittals drawings and wiring diagrams.

B. Position each electronic air cleaner unit with clearance for normal service and maintenance. Anchor electronic air cleaners to unit.

C. Power generator shall be wired through the plenum access door safety switches to interrupt line voltage input to the power generator when any of the plenum access doors in the area of the grids are opened per the manufacturer’s diagram and installation instructions.

D. Coordinate electronic air cleaner with air-handling-unit installations.

3.03 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between controlled devices.

C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Electronic air cleaner will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.05 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean electronic cleaners.

3.06 PROTECTION

A. Protect installed products and accessories from damage during construction.

END OF SECTION

SECTION 23 73 13 - MODULAR AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes insulated, double-wall-casing, air-handling units that are factory assembled using multiple section components as specified, scheduled and/or shown on the drawings.

B. Related Sections:
1. Section 23 05 48 "Vibration Controls for HVAC" for vibration isolation devices.
2. Section 23 09 00 “Building Automation Systems” for control end devices furnished and items provided by the BAS contractor.
3. Section 23 33 00 "Air Duct Accessories" for dampers and flexible connectors.
4. Section 23 41 00 "Particulate Air Filtration" for pleated and box filters and filter frames.
5. Section 23 43 00 "Electronic Air Cleaners" for factory-fabricated, modular needlepoint bipolar ionization system (Alternate M-2).
6. Section 23 82 22 "Gas-Fired Steam Humidifiers" for direct-steam-injection panel distribution manifold humidifiers.
7. Section 23 82 16 "Hydronic Air Coils" for cooling, heating and heat recovery coils.

1.02 ACTION SUBMITTALS

A. Product Data: For each air-handling unit, including components provided or furnished as part of the air-handling unit as a single submittal package, even where components are specified in related sections. Refer to related sections for component product data submittal requirements.
1. Unit components, dimensions and required clearances.
2. Unit components.
3. Casing material, metal thickness, finishes, insulation, and accessories.
4. Casing construction details.
5. Weight loads and distributions by component section.
6. Sound Data:
7. Unweighted octave band air-handling unit sound power for inlets and outlets rated in accordance with AHRI Standard 260. Provide eight data points, the first for the octave centered at 63 Hz, and the eighth centered at 8,000 Hz.
8. Unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.
9. Manufacturer shall not use sound estimates based on bare fan data (AMCA ratings), nor use calculations like the substitution method based on AHRI 260 tests of other air-handling unit products.
10. Required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.
11. Electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
12. Static pressure profiles by component section.
13. Panel deflection at +/- 8-inch wg, stated in terms of ‘L/X’ where ‘L’ is the casing panel length and ‘X’ is a constant provided by the AHU manufacturer.
14. Casing leakage rate at +/- 8-inch wg, specified in terms of percentage of design airflow.

B. Air-handling unit plan, elevation and section views shall be provided in a scale no less than 1/4” = 1'-0".

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: For each air-handling unit, provide:
      a. One set of filters at the start of testing, adjusting and balancing (TAB).
      b. One set of filters for final turnover to owner.
   2. Gaskets: One set(s) for each access door.
   3. Belts: One set for each AHU.

1.06 DELIVERY, STORAGE AND HANDLING

A. Comply with ASHRAE 62.1, Section 7 - "Construction and Startup." Protect equipment from moisture by appropriate in-transit and on-site procedures.

B. Follow manufacturer’s recommendations for handling, unloading and storage.

C. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

D. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

E. Enclose and protect control panels, and electronic devices. Do not store equipment in wet or damp areas even when it is sealed and secured.

F. Seal openings to protect against damage during shipping, handling and storage.

G. Wrap indoor units with a tight sealing 8 mil shrink wrap membrane for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion during shipping. Wrapping membrane shall cover entire air-handling unit during shipping and storage. Cover equipment, regardless of size or shape.

H. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

I. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

J. If equipment is to be stored for a period of time prior to installation, the contractor shall remove all shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

K. The unit manufacturer shall ship the unit with blank-off plates shipped loose to allow for any field air leakage testing to occur.

1.07 SOURCE QUALITY ASSURANCE

A. Manufacturer shall have a minimum of 15 years of experience in designing, manufacturing, and servicing air-handling units.

B. Unit shall conform to AMCA 210 for fan performance ratings.

C. Unit shall conform to E.T.L. standards. Unit shall be ETL listed.

D. Unit sound ratings shall be reported in accordance with AHRI 260 for inlet and discharge sound power levels.

E. Unit casing radiated sound ratings shall be reported in accordance with ISO 9614 parts 1&2 and ANSI S12.12.

F. Unit shall conform to AHRI 410 for capacities, pressure drops, and selection procedures of air coils.

G. Unit shall have airflow performance certified to ANSI/AHRI 430.

H. Motors covered by the Federal Energy Policy Act (EPACT) shall meet EPACT requirements.

I. Damper performance shall comply with AMCA 500.

J. Units shall be ISO 9001 certified.

K. Units shall be manufactured in an ISO 9002 certified facility.

L. Filter media to comply with ANSI/UL 900 listed Class I or Class II.

M. Control Wiring comply with NEC codes & ETL requirements.

N. Units shall comply with energy use AHSRAE 90.1.

1.08 COORDINATION

A. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers are acceptable if equipment meets scheduled performance, material and dimensional requirements.

B. If equipment is supplied by a manufacturer other than the basis of design, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. Coordination shall include (but is not limited to) the following:
   1. Structural supports for units.
   2. Size and location of concrete bases/housekeeping pads.
   3. Location of duct slab penetrations.
   4. Ductwork sizes and connection locations.
   5. Piping size and connection/header locations.
   6. Interference with planned ductwork, piping and wiring.
   7. Electrical power requirements and wire/conduit and over current protection sizes.
   8. Trap height requirements.

1.09 WARRANTY

A. Manufacturer agrees to repair or replace components of air handling unit that fail in materials or workmanship within specified warranty period. This warrants that all products are free from defects in material and workmanship.
   1. One year from date of Final Acceptance.

B. Warranty work shall be performed by the manufacturer’s factory-trained and factory-employed technician.

C. Warranty covers all parts except consumable items (filters, fuses). Include factory-provided controls in the parts warranties.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Structural Performance:
   1. Casing Panels: Self-supporting and capable of withstanding positive/negative 8-inch wg internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.
   2. Floor and Roof Panels: Self-supporting and capable of withstanding 300-lb static load at midspan, without exceeding a midpoint deflection of L/240.

F. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8-inch wg.

G. Condensation shall not form anywhere on unit exterior at 51.5°F supply air and 85.0°F DB / 50% RH exterior ambient. Manufacturer shall supply an external condensation performance line, plotted on the psychrometric chart, based on actual test data. Plot will show the exterior conditions at which unit will sweat given the design supply air temperature. Manufacturer shall clearly indicate whether the design conditions will or will not result in external condensation forming anywhere on the unit exterior. If the unit will sweat, indicate where sweating will occur. Unit exterior includes the base, base rail, roof, corners, doors, door frames, and under the cooling coil drain pan.

2.02 MANUFACTURERS

A. Basis-of-Design Product: Provide Daikin Applied Vision or comparable product by one of the following:
   1. Carrier Corporation; a United Technologies company.
   2. Daiken Applied
   3. Temptrol; Nortek Air Solutions
   4. Trane
   5. York/Johnson Controls Inc

B. Source Limitations: Obtain all air-handling units on the project from single manufacturer.

2.03 MATERIALS

A. Steel:
   1. ASTM A 36/A 36M for carbon structural steel.
   2. ASTM A 568/A 568M for steel sheet.

B. Stainless Steel:
   1. Manufacturer's standard grade for casing.
   2. Type 202, ASTM A 240/A 240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A386 or ASTM A525.

D. Aluminum sheet and plate: 3003-H14 alloy, conforming to ASTM B209.

E. Corrosion-Resistant Coating: Coat cabinet with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B 117.
   1. Standards:
      a. ASTM B 117 for salt spray.
      b. ASTM D 1654 for cross hatch adhesion of 5B.
   2. Application: Manufacturer standard.
   3. Thickness: 1 mil.
   4. Gloss: Minimum gloss of 60 on a 60-degree meter.

F. All dissimilar materials are to be properly isolated.

2.04 FRAME AND BASE

A. Frame: Modular with heavy gauge channel posts and panels secured with mechanical fasteners and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:
   1. Material: 12 age G60 formed channel, with cross supports spaced at regular intervals and removable lifting lugs.
   2. Height: Minimum 6-inch, as required for structural rigidity and condensate trapping (including concrete housekeeping pad thickness).
   3. Units shall be provided with base rail and lifting lug system that does not require additional support for rigging. Include base rail lifting lugs at unit corners.
   4. Factory Finish:
      a. Provide manufacturer's standard finish.

b. Factory applied high build (3 to 5 mils) alkyd enamel.
c. Coating shall pass ASTM B-117B 1000-hour salt spray test.
d. Bead blast all surfaces of base and wipe clean all bare metal before painting.

2.05 FLOOR

A. Floorplate:
1. Material: Galvanized steel, minimum 18-gauge thick, full seam welded and sealed to the base with tread plate pattern.
2. Floor shall be insulated with 2-inch polyurethane spray foam insulation, minimum R-13.

B. Subfloor Liner:
1. Material: Galvanized steel, minimum 22 gauge thick, screwed to the base channel.

C. Floor shall be thermally isolated from welded base frame members (perimeter and internal supports).
1. Non-sleeved penetrations through the floor shall not exist. Construction allowing screws or bolts to penetrate floor shall not be allowed.

2.06 CASING WALLS

A. Internal Post Structure: Patented heavy gauge channel posts.

B. Casing Joints: Joints shall be mechanically fastened. Fasteners shall not extend from the outside to the inside of the unit. Use angle to fasten and seal walls at corners, floors, and roofs.

C. Outside Casing Wall:
1. Material: Galvanized steel, minimum 18 gauge thick.
2. Factory Finish:
a. Manufacturer shall paint exterior surfaces of indoor units prior to shipment.
b. Manufacturer shall clean the exterior surfaces of units prior to application of exterior coating.
c. Manufacturer shall apply a primer prior to application of finish coating.
d. Exterior finish coating shall show a breakdown of less than 1/8” on either side of a scribed line when subjected to ASTM B117 1,000-hour, salt spray conditions. This is equivalent to an ASTM D1654 rating of ‘6.’ Also, per ASTM D610, degree of rusting to meet #8-G and per ASTM D714 degree of blister to meet #6 medium.
e. Provide manufacturer's standard finish.

D. Inside Casing Wall:
1. Material: Galvanized steel, solid, minimum 20 gauge thick.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Casing Insulation:
1. Materials: CFC-free injected polyurethane foam insulation, 2.5lbs./cu.ft.
2. Insulation Thickness: 2 inches.
3. Casing Panel R-Value: Minimum R-13.
4. Location: Encased between outside and inside casing.
5. Full Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

F. Sealants: Sealant shall be installed between panels at all joints, between panels and trim, and between panels and base channels to provide an airtight enclosure.
1. Sealant shall be non-sag, non-staining, permanently flexible, and as recommended by the air-handling unit manufacturer for the intended application.

2.07 ROOF

A. Roof: Construction of the roof shall be identical to the wall construction specified.

2.08 ACCESS PANELS AND DOORS

A. Suitably sized access section shall be provided between air handling unit components for accessibility and maintainability.

B. Access Panels:
   1. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as wall casing. Full thermal break construction.
   2. Fasteners: Four or more screws for panel lift-out operation. Arrangement shall allow panels to be opened outward.
   3. Gasket: Bulb-type, applied around entire perimeters of panel frames.
   4. Size: Large enough to allow removal of air-handling unit's internal components.

C. Access Doors:
   1. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as wall casing. Thermal break construction.
   2. Hinges: A minimum two (2) 6-inch stainless steel piano hinge and two roller cam latches, operable from outside. Rotating knife-edge or “paw” latches are not acceptable. Arrange doors to be opened outward with safety catch in positive pressure sections.
   3. Handles: Glass fiber reinforced, UV rated, nylon polyamide.
   4. Gasket: Bulb-type, applied around entire perimeters of panel frames.
   5. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 24 inches wide by full height of unit casing up to a maximum height of 64 inches.

D. Windows:
   1. Construction: Fabricate windows in access doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
   2. Size: Minimum 7 inches, round or square.

E. Locations and Applications:
   1. Access doors with windows shall be provided in each air-handling unit access section and as shown on the drawings.
   2. Access panels shall be provided:
      a. Hydronic coil section, large enough to allow removal of coils.
      b. Fan section, large enough to allow removal of fan assemblies.

F. Test Ports: Ventlok No. 699 instrument test holes installed in every access door location to measure pressure drops across unit.

2.09 CONDENSATE DRAIN PANS

A. Construction:
   1. Double-wall, full welded 16-gauge stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
   2. Minimum of 2” of injected polyurethane foam insulation under the entire bottom surface of the drain pan. Drain pan shall be foam injected as a complete assembly and shall include thermal breaks at connection points to unit casing.

B. Drain Connection:
   1. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
   2. Minimum Connection Size: NPS 1-1/4.

C. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least three planes to collect condensate from cooling and heat recovery coils (including coil piping connections, coil headers, and return bends), and humidifiers and to direct water toward drain connection.

D. Length: Extend drain pan downstream from entering face of coil for distance to comply with ASHRAE 62.1, minimum 24 inches downstream of leaving face of coil.

1. Water droplet carryover beyond drain pan shall be limited to 0.0044 oz/ft2 of face area per hour under peak sensible and peak dew-point design conditions, considering both latent load and coil face velocity.

E. Width: Entire width of water producing device. Extend 1-inch beyond headers and U-bends on each side of coil.

F. Depth: A minimum of 2 inches deep.

G. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
1. Fully welded 16-gauge stainless-steel, IAQ sloped, minimum 1” deep.
2. Provide 1" downspouts of Schedule 80 CPVC or Type K copper, draining to the lowest drain pan.

H. Drain pans shall have a rigid 12” wide safety tread plate walk bridge stretched across the unit width.
1. Walk bridge shall be of the same material type as the unit floor.
2. The walk bridge and support system shall be suspended above the drain pan (not in contact with the drain pan bottom) and shall be easily removable for drain pan cleaning.
3. Safety grates shall be capable of supporting a 300 lb. center load.

2.10 FAN ARRAYS

A. Units shall be provided with an Electronically Commutated Motor (ECM) fan arrays as shown on equipment schedule and drawings.
1. Basis of design shall be the Q-PAC Fan System.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, multiple high performance direct drive, single inlet, plenum fans with backwards inclined, high efficiency welded-aluminum or high-performance composite impeller with galvanized or aluminum and support structure. Fan array shall be listed per UL 1995.

C. Fans:
1. Fans shall be driven by long-life, low-temperature brushless DC electronically commutated motor (EC-Motor) with external rotor and integrated maintenance-free electronic circuitry and electronics.
2. Fans shall be provided with pre-wired power and control harnesses of a standard length corresponding to the fan dimensions such that all fans are interchangeable within a system.
3. Preinstalled fan harnessing shall terminate with plug and socket-style connections, requiring no manual wiring of the power and control cables between the fan motor and quick connect box.
4. Fans shall be rated in accordance with AMCA Sound and Air Performance without accessories by the original manufacturer.
5. Fans shall be equipped with motor overload protection.

D. Motor:
1. The motor shall be manufactured with maintenance-free, permanently lubricated ball bearings and shall be statically and dynamically balanced in accordance with ISO 1940 part 1.
2. The motor shall be closed, protection level IP 54, thermal class 155 with permissible operating temperature of -13°F to 140°F.
3. Motor efficiency class shall comply with IE4.
4. Fan characteristic curves shall indicate measurements on a chamber test in accordance with ISO5801.
5. The three-phase external rotor motor integrated into the fan hub shall meet the requirements for circulating electric machines set forth in DIN EN 60 034-1 (VDE 0530 Part 1).

E. Control Panel:

1. Control panel shall include an external disconnect and shall be UL or ETL listed.
2. Control panel shall comply with UL 508A and be configurable as NEMA 1 for indoor environments.
3. Control panel shall be configured with a kiloampere Interrupting Capacity of 100 kAIC.
4. Control package shall include a Hand-Off-Auto (HOA) Switch, with the ability to bypass the controller for manual control of the system fan speed.
5. Control panel shall be provided with a BACnet compatible controller capable of monitoring the array's airflow, total static pressure, power consumption, RPM, and individual fan alarm status and specific cause of alarm.
6. Controller shall be configurable for fan speed control via BACnet interface (MS/TP), 0-10 VDC input, 4-20 mA input, constant airflow, or duct static pressure (static pressure sensor to be field provided and mounted).
7. Control panel shall be equipped with relays for locking between other electrically driven components. There is a system alarm contact that the BAS can use to check the status of the fan array system.
8. There shall be a system enable contact that the BAS can use to enable or disable the fan array system, along with a safety circuit termination.
9. All components shall be sized to fit through a 20" x 40" access opening.

F. Quick Connect Box:
1. Quick connect box shall be UL 508A Recognized.
2. Quick connect box shall include overcurrent protection for each fan in the system.
3. Quick connect box shall include wiring terminations for the power and control wiring from each fan in the system prior to connection to the Control Panel.
4. Quick connect box wiring terminations shall be of plug and socket-style, requiring no manual wiring of the power and control cables between the fan motor and quick connect box.

G. Bulkhead Wall:
1. Bulkhead wall assembly shall be constructed of 14 Gauge G90 formed sheet metal panels.
2. Bulkhead wall assembly shall contain cutaways consistent with the fan inlet cone and rivet nuts consistent with the mounting hole pattern of the fan plate.
3. Sheet metal panels of the bulkhead wall shall be designed for easy field transport and assembly, able to fit through a 21" x 40" opening.
4. Sheet metal panels shall be provided with pre-punched hole patterns matching adjacent panels and other applicable wall equipment for modular installation of supplemental components.
5. Sheet metal panels shall have a bend profile providing structural support for the finished wall assembly.
6. Sheet metal panels shall be provided with labels reflecting their installation order and relative location, as well as labels for any location-specific components.
7. Sheet metal panels designed for fan installation shall include a sheet metal ledge per fan installation location designed to support the weight of the fan during installation.

H. Backdraft Damper:
1. Backdraft dampers shall be provided for automatic isolation of individual fans in lieu of blank-off plates.
2. Backdraft dampers shall be made from materials consistent with the unit interior.
3. Backdraft dampers shall be designed with a smooth transition to increase fan efficiency and damper to have no adverse system effect on the fan.
4. Backdraft dampers shall be designed to remain open at all times except under the loss of a fan in the array, where the disabled fan backflow preventer will close, while the other fans remain in operation.

I. System shall be installed in the airstream with sufficient structural support for the perimeter angle of the bulkhead wall assembly or utilizing an existing flange having sufficient support for the wall panels directly.

J. System installation shall be arranged for sufficient access area for service and maintenance.

K. Fan system manufacturer must stock replacement parts in North America.

2.11 HYDRONIC AIR COILS

A. Units shall be provided with hydronic coils as shown on equipment schedule and drawings.

B. Refer to Section 23 82 16.11 "Hydronic Air Coils" for chilled, heating and heat recovery water coil product data and additional requirements. Hydronic coils shall be provided by the air-handing unit manufacturer.

C. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s). Coils shall be removable from the side of the AHU.
   1. For units with multiple stacked coils, provide a stacking rack to allow individual coils to be removed from side of AHU without disturbing any other coils.

D. A single intermediate vertical coil support shall be provided on coils with a finned length greater than 62."

E. Provide coils with a maximum face velocity as scheduled. Face velocity calculations shall be based on the finned area of the coil.

F. Access shall be provided of at least 24" between coils. Access panel or door shall be easily operable and are easily removable with no special tools, as shown on drawings.

G. Connections shall be factory piped through the casing wall with a minimum extension beyond the casing exterior of 5 inches. Internal unions shall be provided.

H. Gap between coil stub out connection and AHU casing, shall be insulated with a spool-shaped sleeve grommet. Adhesive rings applied to the casing walls shall not be acceptable.

I. Locate access doors near coil connections to provide minimum clearance of 2 inches for field installed external piping insulation. Space shall allow a minimum of 90 degrees of door swing.

2.12 AIR FILTRATION

A. Units shall be provided with air filtration as shown on equipment schedule and drawings.

B. Refer to Section 23 41 00 "Particulate Air Filtration" for particulate air filtration product data and additional requirements. Particulate air filtration, filter frames and filter gages shall be provided by the air-handing unit manufacturer.

C. Mounting Frames: Welded 18-gauge galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
   1. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
   2. Access: Upstream or side.
   3. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between foam gasketed filter elements and to prevent bypass of unfiltered air.
   4. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.
   5. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
   6. Designed to accommodate standard size filters with the application of the appropriate type fastener.
   7. Sized to accommodate the filters scheduled on the drawings.

D. Filter Gages: Magnehelic diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

E. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters.

2.13 ELECTRONIC AIR CLEANERS (ALTERNATE M-2)

A. For Alternate M-2, all air handling units shall be provided with modular needlepoint bipolar ionization system as shown on equipment schedule and drawings.

B. Refer to Section 23 43 00 "Electronic Air Cleaners" for modular needlepoint bipolar ionization system product data and additional requirements. Bipolar ionization system shall be provided by the air-handing unit manufacturer.

C. General Requirements:
   1. Maximum Design Air Velocity: Humidifier panel to be selected with maximum face velocity of 650 FPM.

D. Installation
   1. Bipolar ionization system shall be sized by the manufacturer and installed in the factory in accordance with the manufacturer’s installation, operation, and maintenance manual unless otherwise specified.

2.14 STEAM HUMIDIFIER

A. Air handling units AHU-1A and AHU-3B shall be provided with steam dispersion manifolds as shown on equipment schedule and drawings.

B. Refer to Section 23 82 22 "Gas-Fired Steam Humidifiers" for direct-steam-injection panel distribution manifold product data and additional requirements. Direct-steam-injection panel distribution manifold shall be provided by the air-handing unit manufacturer and be compatible with the mechanical contractor provide gas-fired steam humidifier generator.

C. General Requirements:
   1. Maximum Design Air Velocity: Humidifier panel to be selected with maximum face velocity of 650 FPM.
   2. Absorption distance: Shall not exceed 24 inches at design conditions. Air handling manufacturer shall be responsible for proper absorption distance for steam between humidifier and downstream components.

D. Installation
   1. Piping and trapping of all humidifiers shall be installed by others in the field in accordance with the humidifier manufacturer’s installation, operation, and maintenance manual unless otherwise specified.
   2. Humidifier panel to be mounted on a stainless-steel support structure. The support structure shall locate the bottom of the humidifier a minimum of 20 inches above the bottom of the air handling unit base for proper draining/trapping.
   3. Humidifier shall be provided with stainless steel flashing between humidifier and casing walls to prevent air bypass if required by the humidifier selection.
   4. Steam supply and condensate return connections shall extend through the AHU casing wall and be sealed air and watertight.
   5. If the air handling unit is not provided a service corridor, condensate connections requiring “P” trapping shall be located a minimum of 12 inches above the bottom of the air handling unit base for proper trapping. If the air handling unit is provided a service corridor, condensate connections requiring “P” trapping shall be located a minimum of 12 inches above the air handling unit floor for proper trapping.

2.15 DAMPERS

A. Units shall be provided with the following air duct accessories as shown on equipment schedule and drawings.

B. Refer to Section 23 33 00 "Air Duct Accessories" and Section 23 09 00 "Building Automation Systems" for smoke isolation and control damper product data and additional requirements.

1. Smoke isolation dampers and control dampers shall be provided by the air-handing unit manufacturer.
    a. All air-handing unit control damper actuators shall be furnished by the BAS manufacturer and field installed by the BAS Controls Contractor.
2. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
3. All dampers used for throttling airflow control shall be of the opposed blade type arranged for normally open or normally closed operation, as required.

C. Outdoor, Return-, and Relief-Air Control Dampers:
1. Type:
    a. Recirculating Air Handling Units (AHU-1B, AHU-2, AHU-3A, AHU-3B): Opposed blade.
    b. 100% Outdoor Air Handling Units (AHU-1A): Parallel blade.
2. Material: Galvanized steel. Provide extruded aluminum in units with aluminum inside casing wall.
3. Leakage: Class IA.
4. Damper Operators: Provided by BAS contractor. Refer to Section 23 09 00 "Building Automation Systems."

D. Isolation Dampers:
1. Type: Parallel.
2. Material: Galvanized steel. Provide extruded-aluminum in units with aluminum inside casing wall.
3. Leakage: Class I.
4. Damper Operators: Comply with requirements in Section 23 09 00 "Building Automation Systems."

2.16 FACTORY MOUNTED CONTROLS

A. Automatic temperature components shall be furnished under Section 23 09 00 "Building Automation System" and factory installed by the air handling unit manufacturer. Controls contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings.
1. Refer to Section 23 09 00 "Building Automation System" for “Fan Inlet Airflow Measuring Station”.

2.17 PIPING

A. Factory shall extend all piping connections through casing for field connection.

B. All piping insulation shall be field applied by the installing Contractor. The unit manufacturer shall pressure test any factory piping. Certification of this test shall be included in the I.O.M. manuals.

2.18 ELECTRICAL

A. General
1. All electrical wiring shall be in conformance with the N.E.C.
2. All wiring shall be 600 volt rated type M1W/TTHN stranded copper, enclosed in 3/4-inch diameter or larger, EMT galvanized conduit. Connections to all fans shall be made with a minimum 3-foot length of 3/4-inch diameter or larger FMC. All junction boxes shall be U.L. approved and gasketed.
3. All wiring shall be routed above access doors and panels and shall be not less than 12" above the unit interior floor.
4. On units that ship in sections, wiring between sections must be field installed by others.
5. All permanent and temporary conduit termination points shall be sealed to prevent moisture from entering the conduit.

6. All control and instrument wiring shall be identified with a unique wire number. These numbers shall agree with the numbers shown on the supplier's wiring diagrams. Control circuit wiring shall be permanently identified with wire markers applied within 1" of each terminal and splice.

B. Power Wiring
   1. Unit shall be completely factory wired and shall be arranged to accept the single point connections indicated below. Unit manufacturer shall furnish, install and wire single point power panel (SPPP) with non-fused disconnect on the exterior wall of the unit for each connection to by the electrical contractor.
   2. AHU manufacturer shall:
      a. Provide factory mounted Single Point Power Panel (SPPP) for the following circuits:
         1) 3-phase 480-volt power connection for supply fan array.
         2) 3-phase 480-volt power connection for exhaust/return fan array.
         3) 1-phase 120-volt power connection for bipolar ionization air cleaner (Alternate M-2).
      b. Provide factory mounted and wired Manual Motor Protection (MMP) for each fan in the fan arrays.
         1) MMP device shall consist of a motor overload relay with adjustable current rating and an on-off disconnect switch for power isolation. Field wiring of MMP’s to fan motors shall not be permitted.
         2) MMP devices for a fan array shall be contained in a single MMP control panel and shall be mounted on the exterior wall panel of the fan array section.
         3) MMP panel, if not included in the array controller, shall have a single point of connection for input power wiring and shall feed power individual MMP’s through a common busbar. Independent wiring of input power to individual MMP’s shall not be permitted.
      c. Provide power wiring from the 480v motor circuit SPPP to each fan respective MMP.
      d. Provide power wiring from the 120v lighting to the associated component light switches.
   3. Electrical contractor shall:
      a. Provide input power wiring to the 480v SPPP and 120v SPPPs.
      b. Provide input power wiring to the component light switches.
   4. Lighting circuit shall remain functional when motor circuit disconnect is in "OFF” position.

C. Lighting Systems
   1. Lights:
      a. Factory shall provide vapor resistant, marine type LED lighting fixture in each compartment, placed for optimum viewing without obstructing service access.
   2. Switches:
      a. Factory shall wire each component light fixture(s) to a dedicated 120v switch located adjacent to the component access door.
      b. Switches shall be mounted forty-eight (48) inch high.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for all piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Equipment Mounting: Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.

B. Arrange installation of units to provide access space for service and maintenance.

C. Do not operate fan system until filters are in place.

D. Do not use AHUs for temporary heating, cooling or ventilation unless approved by the Owner. If approved, do not use prior to complete inspection and startup has been performed per this specification.
   1. If AHUs are used during construction, see SMACNA's "IAQ Guidelines for Occupied Buildings under Construction" for procedures to protect HVAC system.
   2. Provide additional sets of AHU prefilters, one for every 4 weeks the units are operated for temporary conditioning during construction.
   3. Replace temporary filters used during construction with new, clean filters at start of test, adjust and balancing.

E. Install AHUs with manufacturer’s recommended clearances for access, coil pull, and fan removal.

F. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter compartment in accessible position. Provide filter gauges on each filter bank, installed with separate static-pressure taps upstream and downstream of filters.

G. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 33 00 "Air Duct Accessories."

H. AHU manufacturer and mechanical contractor shall refer to individual component specifications referenced in this section for installation requirements.

3.03 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest floor or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Insulate plumbing associated with condensate drain pan drains and connections.

3.04 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

3.06 FACTORY INSPECTION AND TESTING

A. Factory test one unit to verify compliance with airflow, static pressure, casing leakage, and panel deflection requirements.
   1. Owner and Design Professional shall select the unit to be tested at completion of fabrication and assembly.
   2. The factory tests shall be recorded on video for a record of procedure and results.
   3. Manufacturer shall cover the cost of food, lodging, and travel expenses for up to two witnesses.
   4. Alternatively to factory testing, field test all units to verify compliance with airflow, static pressure, casing leakage, and panel deflection requirements.

B. Test shall be performed on a fully assembled unit with sections joined per manufacturer's installation instructions. Use of additional material (tape, sealant, caulk) is not acceptable.

C. Perform tests to verify the following performance criteria:
   1. Factory Leak Testing: Casing leaks shall be no more than 1% of design CFM at 1.25 times design static pressure up to a maximum of +8" w.g. in positive pressure sections, -8" w.g. in negative pressure sections.
   2. Factory Panel Deflection Test: Casing panel deflection shall be no more than L/240 at 1.5 times de-sign static pressure up to a maximum of +8" w.g. in positive pressure sections, -8" w.g. in negative pressure sections. 'L' is defined as the panel span length and 'L/X' is the deflection at panel mid-point.

D. Should the selected unit fail a test, all of the units shall be factory tested with a permanent remedy at manufacturer's expense until test is successfully passed.

3.07 FACTORY TEST SETUP AND METHODS (NOT INCLUDED IN BASE BID)

A. AHU Preparation
   1. Assemble and seal AHU sections per manufacturer's installation manual.
   2. Close and latch access doors. No additional sealing is permitted.
   3. Seal duct, damper and louver openings.
   4. Blank off and seal supply fan opening(s).
   5. Blank off and seal supply fan bulkhead, to isolate positive and negative pressure sections.

B. Pressurization procedure
   1. Pressurize positive pressure side (downstream of supply fan wall) to specified static pressures using a pressure blower.
   2. Pressurize negative pressure side (upstream of supply fan wall) to specified static pressures using a pressure blower.
   3. Measure and monitor differential pressure exerted on the cabinet with a pressure gage.

C. Deflection test procedure
   1. Measure panel deflections at the centers (length and width) or four panels chosen by Owner and Design Professional.
   2. Measure pressure drop through either a nozzle fabricated in accordance with ANSI/AMCA Standard 210 or an orifice plate calibrated every 5 years, mounted in the test module.
   3. Monitor leakage at the same time panel deflection is measured.

D. While under pressure, inspect unit failing to meet specified leakage and deflection. Treat failing areas with a permanent remedy. Repeat test and inspection. Re-treat unit as necessary to pass both tests.

E. Provide test data and results, including video, in a complete report to the owner.

3.08 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

1. Delivery: Inspect the units for proper storage, check for damage, and complete initial inspection report to be submitted to the Design Professional. The installing contractor shall coordinate this site visit with the AHU service representative.
2. Assembly: Supervise the work performed by the installing contractor during the rigging and assembly of the unit (s). All tools and labor shall be provided by the installing contractor.
3. Installation: Provide on-site installation specific instructions to the trade contractors regarding piping, electrical, ductwork, and field control wiring connections to the unit. The service representative shall approve all field penetrations to the units, if required.
4. General: Technician shall inspect and verify the following as a minimum:
    a. Damage of any kind.
    b. Level installation of unit.
    c. Proper reassembly and sealing of unit segments at shipping splits.
    d. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
    e. Completion and tightness of electrical, ductwork and piping.
    f. Tight seals around wiring, conduit and piping penetrations through AHU casing.
    g. Supply of electricity from the building's permanent source.
    h. Integrity of condensate trap for positive or negative pressure operation.
    i. Condensate traps charged with water.
    j. Removal of shipping bolts and shipping restraints.
    k. Tightness and full motion range of damper linkages operate manually.
    l. Complete installation of control system including end devices and wiring.
    m. Cleanliness of AHU interior and connecting ductwork.
    n. Proper service and access clearances.
    o. Proper installation of filters.
    p. Filter gauge set to zero.
    q. Leak Test: After installation, charge coils and test for leaks. Repair leaks and retest until no leaks exist.
5. HVAC Fan Assemblies:
    a. Manufacturer shall dynamically balance fan/motor/base assembly.
        1) Balance constant volume fan assemblies at design RPM.
        2) Balance variable volume fan assemblies from 10% to 100% of design RPM.
        3) Take filter-in measurements in the horizontal and vertical axes on the drive and opposite-drive sides of fan shafts.
        4) Constant speed fan vibration limits: filter-in measurements shall not exceed 4 mils.
        5) Variable speed fan vibration limits: filter -in measurements shall not exceed 7 mils.
    b. Manufacturer shall hi-pot test wiring intended to carry voltages greater than 30VAC.
6. Particulate Air Filtration:
    a. Check for leakage of unfiltered air while system is operating.
7. Hydronic Air Coils:
    a. Straighten bent fins on air coils.
    b. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.09 STARTUP SERVICE

A. Engage manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Technician shall perform the following steps as a minimum:
    1. Energize the unit disconnect switch

2. Verify correct voltage, phases and cycles
3. Energize fan motor briefly (“bump”) and verify correct direction of rotation.
4. Re-check damper operation; verify that dampers are in their normal position and verify that unit cannot and will not operate with all dampers in the closed position.
5. Energize fan motors and verify that motor FLA is within manufacturer’s tolerance of nameplate FLA for each phase.

B. Submit a startup report summarizing any problems found and remedies performed.

3.10 ADJUSTING

A. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

B. Dampers:
1. Adjust damper linkages for proper damper operation.

3.11 CLEANING

A. After completing system AHU installation and startup service, and after completing TAB of the air-handling unit and air-distribution systems, and prior to acceptance by the Owner, thoroughly clean the outside and particularly the inside of air-handling units to remove all foreign material and construction dirt and dust.

B. Industrial grade cleaners can be used to remove construction dust. Any sheet metal mil finish or grease can be removed with Freon TF solvent fluorocarbon. All proposed cleaning materials shall have contents identified and approved prior to use.

C. Install new, clean filters.

3.12 DEMONSTRATION

A. Engage a manufacturer’s factory-trained and factory-employed service technician to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units and all components. Training shall include AHU controls.

B. If the manufacturer’s factory-trained and factory-employed service technician is not qualified to train on specific components within the air-handling unit, that component’s factory-authorized service representative shall also participate in the training.

C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.

END OF SECTION

SECTION 23 81 26 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

B. Related Sections:
   1. Section 23 21 23 "Hydronic Pumps" for split system automatic condensate pump units.

1.02 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

G. Sustainability Submittals:
   1. Manufacturers' product data for refrigerants, including printed statement that refrigerants are free of HCFCs.

1.03 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1 - 2022, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1 - 2022, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

E. Units shall be designed to operate with HCFC-free refrigerants.

1.04 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations.

1.05 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Final Acceptance.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Daiken
   2. Mitsubishi Electric/HVAC.
   3. Koldwave, Inc.
   4. LG Electronics
   5. Trane Company (The); Unitary Products Group.

2.02 INDOOR UNIT

A. Unit Cabinet:
   1. The casing shall have a white finish – Munsell 1.0Y 9.2/0.2.
   2. Multi directional drain connection and refrigerant piping, offering three (3) direction pipe alignments for all refrigerant piping and two (2) direction pipe alignments for condensate draining shall be standard.
   3. There shall be a separate, metal back-plate that secures the indoor unit firmly to the wall. Secure mounting of plate and all mounting hardware shall be furnished by and be the responsibility of the installer.

B. Fan:
   1. The indoor unit fan shall be an assembly with a line-flow fan direct driven by a single motor.
   2. The fan shall be statically and dynamically balanced and be powered by a motor with permanently lubricated bearing.
   3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
      a. Indoor units shall have a "Wide Vane" feature to distribute airflow over a wide – 150 degree – angle from right to left to provide comfort over a wider area.
   4. An integral, motorized, multi-position, horizontal air sweep flow louver shall provide for uniform air distribution, up and down.
   5. The indoor fan shall operate at of four (4) selectable speeds: Powerful, High, Medium and Low.

C. Filter:
   1. Return air shall be filtered by means of easily removed, washable, Catechin, Antioxidant Pre-filter and an Anti-allergy enzyme filter – blue, pleated type.

D. Electrical:
   1. The unit electrical power shall be 208-230 volts, 1-phase, 60 hertz.
   2. The system shall be equipped with A-Control – a system directing that the indoor unit be powered directly from the outdoor unit using a 3-wire connection plus ground.
   3. The indoor unit shall not have any supplemental electrical heat elements.

2.03 OUTDOOR UNIT

A. Unit Cabinet:
   1. The casing shall be fabricated of galvanized steel, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection.
   2. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

B. Electrical:
   1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
   2. The unit shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.
   3. The outdoor unit shall be controlled by the microprocessor located in the indoor unit and outdoor unit.

4. The outdoor unit shall be equipped with Pulse Amplitude Modulation (PAM) compressor motor control for maximum efficiency.

2.04 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan with the following features:
   1. Compressor time delay.
   2. 24-hour time control of system stop and start.
   3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   4. Fan-speed selection including auto setting.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Provide ASHRAE 135 Bacnet Interface to integrate points directly into the BAS. Include separate thermostat for BAS monitoring of space conditions and Hi Room Temp alarming..

PART 3 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounting, compressor-condenser components on 4-inch- thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install roof-mounting compressor-condenser components on equipment supports specified in. Anchor units to supports with removable, cadmium-plated fasteners.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

A. Install piping adjacent to unit to allow service and maintenance.

B. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 23 82 16 - HYDRONIC AIR COILS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes hydronic heating and cooling air coils.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
   2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.03 COORDINATION

A. Coordinate size, location and installation of coils with air-handling units to suit conditions and to ensure proper operation.

PART 2 PRODUCTS

2.01 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.02 COILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aerofin
   2. Daikin
   3. Heatcraft Worldwide Refrigeration
   4. RAE Coils; a division of RAE Corporation
   5. Temtrol
   6. Trane
   7. USA Coil & Air

B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 300 deg F.

D. Source Quality Control: Factory tested to 300 psig.

E. Tubes:
   1. Material: ASTM B75 and B251 seamless copper tube, internally enhanced.
   2. Outer Diameter: 0.0625 inch.
   3. Wall Thickness: Minimum 0.025 inch.
   4. Return Bend Wall Thickness: Minimum 0.035 inch.
   5. Tube sheets on each end shall have fully drawn collars to support and protect tubes.

F. Fins:
   1. Material: Die-formed aluminum.
   2. Type: Continuous wave plate.
   3. Thickness: Minimum 0.0075 inch.
   4. Spacing: Self-spacing, maximum 12 fins per inch.
   5. Fin and Tube Joint: Mechanical bond.

G. Headers:
   1. Material: ASTM B75 and B251 seamless copper tube with brazed joints, prime coated.
   2. Wall Thickness: Minimum 0.065 inch.
   3. Provide with minimum 1/4 NPT plugged vent and drain tap at the highest and lowest points in the coil.

H. Piping Connections: ASTM B43 Schedule 40 red brass.
   1. 2-inch and smaller: Threaded, same end of coil.
   2. 2-1/2-inch and larger: Flanged, same end of coil.

I. Casing:
   1. Chilled and Heat Recovery Water Coil: 0.0625-inch- thick, stainless steel.
   2. Heating Water Coil: 0.0625-inch- thick, galvanized steel.
   3. Horizontal coil casing and support members shall allow moisture to drain.
   4. Intermediate vertical coil supports shall be same material as casing.
   5. Double-flange casing shall be provided when coils are vertical stacking.
   6. Coating: None.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine air-handling unit casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install coils level and plumb.

B. Straighten bent fins on air coils.

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

END OF SECTION

SECTION 23 82 19 - FAN COIL UNITS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes fan-coil units and accessories.

1.02 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension components.
   2. Structural members to which fan-coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For fan-coil units include the following:
   1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

G. Warranty: Special warranty specified in this Section.

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.04 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.05 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Provide one replacement fan motor for each motor size used.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Compressor failure.
   b. Condenser coil leak.
2. Warranty Period: Five years from date of Final Acceptance.

PART 2 PRODUCTS

2.01 DUCTLESS FAN COIL UNITS

A. Manufacturers:
   1. Carrier Corporation.
   2. McQuay International.
   3. Trane.
   4. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1/2-inch thick, foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

D. Main and Auxiliary Drain Pans: Stainless steel formed to slope from all directions to the drain connection as required by ASHRAE 62. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint.
   1. Vertical Unit Front Panels: Removable, steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with discharge grilles.
   3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected from manufacturer's standard colors. Return grille shall provide maintenance access to fan-coil unit.
   4. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Washable Foam: 70 percent arrestance and 3 MERV.
   2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
   3. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. ECM motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Controls:
   1. Refer to Section 23 09 00 "Building Automation System" and drawings for interface to the building automation system and sequence of operation.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

L. Capacities and Characteristics: Refer to equipment schedule on the drawings for additional information.

M. All fan coil units, if the interior insulation is exposed to the air stream, the insulation shall have an anti-microbial coating or foil faced insulation may be provided.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Final Acceptance.

F. Clearances around fan coil units shall be sufficient to allow inspection, service, repair or replacement without removing elements of permanent construction and in accordance with the manufacturer’s recommended clearances. Coordinate with all other trades to protect the service area around equipment.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
   3. Connect condensate drain to indirect waste.
      a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26.

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.05 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Final Acceptance, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units.

END OF SECTION

SECTION 23 82 22 – GAS-FIRED STEAM HUMIDIFIERS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Free standing, self-contained gas-fired steam humidifier system.
   2. Steam dispersion panel.

B. Related Requirements:
   1. Section 23 09 00 "Building Automation System" and drawings for gas-fired steam humidifier interface to the building automation system.
   2. Section 23 73 13 “Modular Air-Handling Units” and drawings for double-wall, air-handling units for installation of steam dispersion panels.

1.02 DEFINITION

A. Retain definition that remains after this Section has been edited.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Structural members to which humidifiers will be attached.
   2. Size and location of initial access modules for acoustical tile.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.05 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Supply one replacement electrode cylinder with each self-contained humidifier.

1.06 COORDINATION

A. Coordinate size, location and installation of humidifier steam dispersion panel with air-handling units to suit conditions and to ensure proper humidifier operation.

PART 2 PRODUCTS

2.01 SELF-CONTAINED GAS-FIRED HUMIDIFIER SYSTEM

A. Basis-of-Design Product: Provide Dristeam GTS LX-200 High Efficiency Gas-Fired Evaporative Steam Humidification System or comparable product by one of the following:
   1. Armstrong International, Inc.
   2. Dri-steam
   3. Humidifier.
   4. Nortec Industries Inc.

B. Humidifier Performance:
   1. Unit shall be of a condensing design utilizing a secondary heat exchanger to achieve average thermal efficiencies of over 93%.
   2. The high-efficiency humidifier shall be certified by South Coast Air Quality Management District (SCAQMD) to meet low NOx requirements of Rule 1146.2.

C. Fabrication
   1. Tank and primary heat exchanger: 14-gauge 316-stainless steel with water side welded seams for all water-submerged welds.
   2. Humidifier shall include a 316 stainless steel secondary heat exchanger to pre-heat inlet water and combustion air using exhaust gasses exiting the primary heat exchanger.
   3. Tank bottom shall be slanted with drain port at bottom of tank to ensure complete draining.
   4. Steam outlet on top of tank configured to connect to hose and pipe (NPT or BSP connection) for units up to 150 lbs/hr, and only pipe (NPT, BSP, or flange connection) for units from 200 lbs/hr to 600 lbs/hr.
   5. Humidifier must be designed and approved by manufacturer to safely operate with polypropylene (PP) flue venting.
   6. Unit shall include adaptable fittings to utilize polypropylene (PP) inlet and flue venting material as required by local codes.
   7. Include removable cover allowing easy access to water sensing assembly in the tank.
   8. Tank shall have an easily accessible cleanout plate.
   9. Indoor humidifier shall have a painted aluminum enclosure to protect all humidifier components and have an integral base with openings designed for moving humidifier with a forklift or pallet jack.
   10. Humidifier tank shall be insulated with 1/2"-thick (12.5 mm), K-Flex closed cell insulation.
   11. Units shall be capable of fitting through a 36" wide door.
   12. Humidifier shall have sealed combustion plumbed to the unit shroud.

D. Burner Assembly:
   1. Humidifier and burner assembly shall be CSA/AGA/CGA/ETL certified and tested to support natural gas.
   2. Gas train assembly shall be complete with burner/mixing tube assembly, igniter, sight glass, flame rod electrode, gas manifold, integral gas valve and venturi.
   3. Each burner shall freely modulate with a gas input turndown ratio of at least 5:1.

E. Water Type, Fill and Drain
   1. The humidifier shall be capable of generating steam from well, tap, softened, DI or RO water.
   2. The humidifier shall not require changes to controls or components in the field due to changes in water type.
   3. The humidifier shall sense water purity and automatically adjust drain rates accordingly to minimize tank maintenance and optimize water usage.
   4. Fill and drain line piping shall include anti-siphoning mechanisms that prevent tank siphoning and potential inlet water contamination.
   5. Humidifier shall incorporate a water surface skimming feature to drain away water surface debris and contaminants to minimize tank cleaning maintenance and risk of foaming.
   6. An electric drain valve shall be mounted on humidifier assembly to allow tank to drain automatically at the end of a humidification season.
      a. Provide complete tank draining with no standing water.
      b. Minimum 5 gpm flow rate for fast draining.

c. The system shall monitor drain water temperature with temperature viewable on the unit's display.

7. Integral water tempering control shall meter cold water at the drain in order to temper 212°F water to a maximum 140°F discharge temperature at full drain rate to sanitary system during normal operation.
   a. Drain water tempering shall employ closed loop feedback using the drain temperature sensor to automatically control the drain and fill valves. Drain water temperature shall not exceed 140°F while system shall minimize (cold) water usage by not excessively tempering.
   b. Minimize drain and refill time by sensing when water is no longer draining (tank empty) to quickly initialize refilling of tank and subsequent re-start of humidification.

F. Combustion Air and Exhaust Vent Kits
   1. Manufacturers
      a. Basis-of-Design Product: Subject to compliance with requirements, provide Centrotherm Innoflue or comparable product by one of the following.
         1) Centrotherm
         2) DuraVent (M&G Group)
      b. The exhaust vent and combustion air intake shall be single wall, factory-built polypropylene (PP), designed for use in conjunction with Category IV condensing gas-fired appliances and an approved material as listed in the Installation and Operations manual.
      c. All system components shall be tested and listed to UL-1738 and supplied by the same manufacturer.
      d. The vent and air intake systems shall be a complete system, continuous from the humidifier to the termination with screen outside the building.
      e. All required systems components such as supports, wall penetrations, terminations, screens, appliance connectors and drain fittings required to install the vent and air-intake systems shall be provided by the manufacturer.
      f. All systems components shall include a factory- installed gasket in their female-end to render the systems air and watertight when the male/female ends are pushed together as per manufacturer's instructions. Systems requiring field installed sealants or compounds shall not be acceptable.
      g. Exhaust Vent:
         1) Maximum continuous flue gas temperature shall not exceed 230 degrees F.
         2) Vent shall be listed for a maximum positive pressure rating of 20" w.c.
         3) Exhaust vent length must be able to extend to 100 equivalent feet.
      h. Combustion-Air Intake:
         1) Combustion-air intake length must be able to extend to 100 equivalent feet.
      i. All outside components must be UV rated where exposed to the atmosphere.
      j. Humidifier venting and intake piping configuration shall be installed per approved venting methods shown in the approved humidifier installation and operation manual.
      k. The exhaust vent and combustion air intake size for each humidifier shall be determined by the manufacturer based on coordinated, project specific layout.

2.02 CONTROLS

A. Control subpanel: Control subpanel shall be factory-attached to humidifier with all wiring between subpanel and humidifier completed at factory. A wiring diagram shall be included.

B. Vapor-logic microprocessor controller with the following features or functions:
   1. Touchscreen user interface shall be included standard on all models
      a. Minimum 5-inch diagonal 800 x 480 24 bit RGB color display
      b. Touch-sensitive screen control including swipe-scrolling of lists
      c. Display operable within a temperature range of 32 to 158°F
      d. Animated graphical display of humidifier operating conditions
      e. Icon-based function keys on screen with consistent Home option to facilitate navigation

f. Setup wizard, context-sensitive Help screens and output test functions for unit commissioning
g. On-screen QR Code links to humidifier installation literature
h. Prioritized color-coded alerts with time & date of occurrence, including log of up to 60 prior event messages.
i. Unit name information; editable with full qwerty on-screen keyboard.
j. Adjacent four-color LED status light of humidifier operating condition

2. Web interface and server:
   a. Web interface shall have same functionality as Vapor-logic touchscreen display
   b. Web interface shall allow multiple remotely located users to simultaneously view system operation and/or change system parameters.
   c. Web interface shall have password-protected secure access.
   d. Web interface shall be compatible with standard Internet browsers.
   e. Web interface shall connect directly to a personal computer or through a system network via Ethernet cable.
3. Touchscreen display shall be factory mounted on humidifier.
   a. For systems that include multiple humidifiers linked together supplying steam to one HVAC system and controlled as one humidification zone, provide one touchscreen display at main humidifier location. One touchscreen to provide status and control of all linked humidifiers.
4. Controller shall provide redundant tank over-temperature and flue over-temperature safety control using inputs from the tank temperature sensor and flue temperature sensor.
5. Humidifier shall have tank over-temperature switch and flue over-temperature switch operating independently of the tank temperature sensor and flue temperature sensor.
6. Include flue temperature sensing to temporarily reduce humidifier output if flue temperatures approach maximum, and to disable unit should maximum flue temperature be reached.
7. Controller shall provide fully modulating control of humidifier capacity.
8. Controller shall provide PID control capability with field-adjustable settings.
9. Water level control:
   a. Provide automatic refill, low water cutoff, surface skimming and automatic drain-down of humidifier. System shall consist of:
      1) A water level sensing unit comprised of three metallic probes mounted in probe head. Probe head shall incorporate probe isolation chamber to eliminate fouling caused by mineral coatings.
      2) Fill valve assemblies factory mounted on the humidifier assembly.
      3) End-of-season drain automatically drains humidifier tank after a user-defined period of system inactivity.
10. Tank temperature sensor: A factory mounted sensor, with a temperature range of -40 to 248°F mounted on the humidifier to enable the following functions:
    a. Maintain the evaporating chamber water temperature above freezing.
    b. Maintain a user-defined preset evaporating chamber water temperature.
    c. Allow rapid warm-up of water in evaporating chamber after a call for humidity, providing 100% operation until steam production occurs.
11. USB port on the control board and touchscreen for software updates, data backups, and data restoration.
12. Up-time optimizer function to keep humidifier(s) operating through conditions such as fill, drain, or run-time faults, as long as safety conditions are met, minimizing production down-time.
13. Real-time clock to allow time-stamped alarm/message tracking, and scheduled events.
14. Factory commissioning of humidifier and control board, including system configuration as-ordered, factory unit testing, and operation with water before shipping.
15. Alarms, unit configuration, and usage timer values shall remain in nonvolatile memory indefinitely during a power outage.
16. The capability to monitor, control, and/or adjust the following parameters:

a. Relative humidity (RH) set point, actual conditions in the space (from humidity transmitter), RH offset.
b. Dew point set point, actual conditions in the space (from dew point transmitter), dew point offset.
c. Relative humidity (RH) duct high limit set point (switch) and actual conditions.
d. Relative humidity (RH) duct high limit set point, actual conditions (from transmitter), high limit span, and high limit offset.
e. Total system demand in % of humidifier capacity.
f. Total system output in lbs/hour.
g. Drain/flush duration, allowed days, and frequency based on usage.
h. End-of-season drain status and hours humidifier is idle before end of season draining occurs.
i. Window glass surface temperature (in % RH offset application using sensor ordered as an option) with programmable offset.
j. Air temperature or other auxiliary temperature monitoring with programmable offset.
k. System alarms and system messages, current and previous.
l. Adjustable water skim duration.
m. Programmable outputs for remote signaling of alarms and/or messages, device activation (such as a fan), or for signaling tank heating and/or steam production.
n. System diagnostics that include:
    1) Test outputs function to verify component operation.
    2) Test humidifier function, by simulating demand to validate performance.
    3) Data collection of RH, water use, energy use, alarms, and service messages for download to USB.
o. Password-protected system parameters
p. Touchscreen display or Web interface displays in English, French, Spanish, Dutch or German languages.
q. Numerical units displayed in inch-pound or SI units.

C. Interoperability using BACnet IP. Coordinate requirements with BAS provider. Building automation systems are specified in Section 23 09 00 "Building Automation System." Provide point data in BACnet IP format to Division 25.

D. Accessories:
1. Humidistat: Wall Exhaust-duct-mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
2. Duct-mounting, high-limit humidistat.
3. Airflow switch for preventing humidifier operation without airflow.
4. Condensate neutralizer: Provide a condensate neutralizer to treat condensate that forms in flue piping and the humidifier’s secondary heat exchanger.
    a. Neutralizer to contain media that neutralizes the condensate water, raising the pH to near neutral.
    b. The neutralizer shall be piped so to drain both flue and heat exchanger condensate to the neutralizer inlet.
    c. Drain piping to and from neutralizer shall be unrestrictive to prevent condensate backup into humidifier heat exchanger.
    d. Neutralizer life shall be size to perform a minimum one year at 30% humidifier run hours, to be replaced when discharge condensate pH fall below 5.0.

E. Capacities and Characteristics: Refer to Schedule.

2.03 STEAM DISPERSION PANELS

A. Basis-of-Design Product: Provide Dristeam Ultra-sorb Model LV Stean Dispersion Panel Humidifier or comparable product by one of the following:
1. Armstrong International, Inc.
2. Dri-steam
3. Humidifier.
4. Nortec Industries Inc.

B. The steam dispersion panel shall directly inject pressurized steam into air handling units AHU-1A and AHU-3B for humidification. Coordinate size and installation requirements of steam dispersion panel with approved air-handling unit manufacturer.

C. Steam, dispersion panels shall be factory-assembled and include the following components:
   1. Steam supply header/separator.
   2. Condensate collection header.
   3. Closely-spaced steam dispersion tubes spanning the distance between the two headers.

D. Each dispersion tube shall be fitted with two rows of steam discharge tubelets inserted into the tube wall, centered on the diametric line, and spaced 1.5" apart. Each tubelet shall be made of a thermal-resin material designed for high steam temperatures. The two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.

E. Each tubelet shall extend through the wall of and into the center of the dispersion tube and contain a steam orifice sized for its required steam capacity.

F. The humidifier shall provide absorption characteristics that preclude water accumulation on any in-AHU surface within 24" of the humidifier tube panel.

G. Each packaged humidifier panel assembly of tubes and headers shall be contained within a stainless steel metal casing to allow for air-handling unit mounting, or to facilitate the stacking of and/or the end-to-end mounting of multiple humidifier panels in air handler casings. When so designated, the humidifier panel shall be shipped unassembled.

H. All tubes and headers shall be 316 stainless steel, and welded joints shall be Heli-arc welded.

I. Tubes shall be joined to headers with slip-fit couplings to facilitate easy removal.

J. Dispersion tubes shall be insulated with a plenum-approved insulating material for in-duct installation and have an R-value not less than 0.5 at a thickness not more than 0.125", for minimal increase in dispersion tube diameter. Insulating material shall meet the following criteria at 0.125" thickness:
   1. Fire/smoke index shall be 0/0 per any of the following test procedures: - UL 723 fire/smoke index (Test for Surface Burning Characteristics of Building Materials) - NFPA 255 (Standard Method of Test of Surface Burning Characteristics of Building Materials) - ASTM E84 (Surface Burning Characteristics for Materials Used in Plenums)
   2. Stable up to 300°F continuous — to prevent material degradation, hardening, or crumbling at high temperatures.
   3. Closed-cell construction does not absorb water or support microbial growth — to negate the need for vapor barriers and jackets.
   4. Non-toxic and pure as documented in manufacturer's data — to prevent off-gassing and to facilitate use in clean rooms, pharmaceutical applications, and food industries.
   5. Will not degrade when exposed to UVC light — to negate the need for UV wraps.
   6. Continuous, seam-welded, and held in place without bands or clamps — to minimize surfaces for the accumulation of particulate matter.

K. Steam trap(s):
   1. Humidifier shall have one or two float and thermostatic (F&T) traps.

L. Accessories:
   1. A thermostatically controlled water valve shall meter an amount of cold water into a stainless steel mixing chamber to temper 212°F water with a 6 gpm in-flow rate to a 140°F discharge temperature to sanitary system.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine air-handling units and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install humidifiers with required clearance for service and maintenance.

B. Seal humidifier manifold penetrations with flange.

C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Install stainless-steel drain pan under each manifold mounted in an air handler.
   1. Construct drain pans to comply with ASHRAE 62.
   2. Connect to condensate trap and drainage piping.
   3. Extend drain pan upstream and downstream from manifold a minimum of 24 inches or as recommended by manufacturer.

E. Install manifold supply piping pitched to drain condensate back to humidifier.

F. Install drip leg upstream from steam trap a minimum of 12 inches tall for proper operation of trap.

G. Install steam generator level on concrete base.

H. Concrete Bases: Anchor steam generator to concrete base.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

I. Install gas-fired steam generators according to NFPA 54.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Install piping adjacent to humidifiers to allow service and maintenance.
   2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

C. Install piping from safety relief valves to nearest floor drain.

D. Connect gas piping full size to steam-generator, gas-train inlet with union.

E. Connect breeching full size to steam-generator outlet.

F. Connect combustion-air inlet to intake terminal using polypropylene (PP) piping. Run from humidifier connection to outside and terminate adjacent to flue termination.

G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION

SECTION 25 15 10 - MASTER SYSTEMS INTEGRATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Division 22 – Plumbing specifies requirements for plumbing systems control.

B. Division 23 – Heating, Ventilation, and Air-Conditioning (HVAC) specifies requirements for HVAC and other mechanical systems.
   1. Section 23 09 00 “Building Automation System” sets forth the requirements of the System Integrator (Controls contractor) who shall work closely with the Master System Integrator to seamlessly integrate the enterprise BAS front end to the field controllers (and building supervisory controllers, when present).
   2. Section 23 09 93 “Sequence of Operations” sets forth the requirements of the sequence of operations.

C. Division 26 – Electrical specifies electrical power system, lighting, lighting control and other electrical systems.

D. Division 27 – Communications specifies data communication systems.

1.02 SUMMARY

A. The MSI work shall include integrating DDC Controls and connecting to the EMIS, include building data into the Skyspark Software. Integration shall be complete prior to Commissioning and building turnover.

B. Refer to Alternate M3 for base bid scope and alternate scope.

1.03 DESCRIPTION

A. Scope: This section contains general requirements for providing Master System Integration, and control programming elements for control systems provided elsewhere in these specifications (software already exists):
   1. Automated graphic application software for building systems monitored and controlled digitally that work in HTML5.
   2. Graphics playback mode requiring no work to implement.
   3. System database for recording controller programs and the data produced by them.
   4. Built in tools for Haystack tagging and data modeling convention for ease of searching and organizing gathered data.
   5. Programming tools for block and line type system programming.
   6. Control logic routines when written once, can be used thousands of times.
   7. Enterprise normal and event scheduling capabilities.
   8. Plug-in an analytics engine that can use the native system database and conventions.
   9. Enterprise integration capabilities - equipment to site and site to site.
   10. Operating system agnostic software applications that will run on several operating systems.
   11. Fault detection diagnostics module.
   12. Secure running application software not penetrable by nefarious means.
   13. Network aware and web aware programs that can run on Apple app-store and Google Play store applications.
   14. Operation not dependent on JAVA applets and JAVA plug-ins.
   15. 64-bit software that can utilize up to 32 GB of system memory.
   16. 64-bit software that can run on a virtual server with full functionality.

B. Purpose: Energy monitoring, process control, remote start/stop and remote set point adjust control of the pumps, heat exchangers, heating water system, AHUs, heat recovery system, exhaust fans, laboratory exhaust fans, exhaust fans, terminals units, laboratory control system, and other items as specified and as shown on the drawings.
   1. Base system software on server/thin-client architecture, designed around the open standards of web technology.

a. Access the control system server using a web browser over the control system network, the Owner's local area network and remotely via the Internet (through the Owner's VPN).

2. The intent of the thin-client architecture is to provide operators complete access to the control system via a web browser.
   a. No special software other than a web browser shall be required to access graphics, point displays and trends, configure trends, configure points and controllers or to edit programming.
3. Work Specified in this Section:
   a. WTCC has chosen FIN Stack (FIN), developed by J2Innovations – a wholly owned subsidiary of Siemens AG, as the BAS enterprise software hosted on a WTCC server. FIN is designed to be open; supporting all the major protocol standards used in buildings today, to enable integration with multiple building level systems and IoT deployments.
      1) Unless directed otherwise by the Wake Tech BAS Engineer or the Wake Tech Project Manager, the Master System Integrator (MSI) shall only integrate from the Building Level equipment controllers to the existing Enterprise Server.
      2) WTCC requires the Master System Integrator (MSI) to be a FIN Certified Integrator with experience integrating through BACnet and nHaystack connections.
      3) It is WTCC's goal to integrate from high level field controllers (e.g., a B-BC or B-AAC) to a FIN front end server to be a single location to view graphics, and interact through point overrides, and to manage alarming, scheduling and trending (AST).
      4) The Owner, Wake Technical Community College, shall be the named license holder of all FIN software associated with any and all incremental work on the projects.
   b. Support Third Party Commissioning Agent.
   c. Train Owner personnel in the operation, maintenance, and service of the control system.

C. The Master System Integrator (MSI) shall follow requirements of the WTCC BAS guideline Section 3 EMIS – Energy Management Information Systems and consult with the WTCC Project Manager and BAS Engineer when providing MSI services.

1.04 PERFORMANCE

A. Performance Standards: System shall conform to the following minimum standards over networked connections:
   1. Graphic Display: A graphic with 20 dynamic points shall display current data within 10 seconds.
   2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 seconds.
   3. Object Command: Devices shall react to command of a binary object within 2 seconds and shall begin reacting to command of an analog object within 2 seconds.
   4. Object Scan: Data used or displayed at a controller or workstation shall have been current within the previous 6 seconds.
   5. Alarm Response Time: Annunciate an object that goes into alarm to any designated workstation(s) within 30 seconds.
   6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds.
      a. Select execution times consistent with the mechanical process under control.
   7. Multiple Alarm Annunciations: Each workstation on the network shall receive alarms within 5 seconds of initiation.
   8. Reporting Accuracy: System shall report values with minimum end-to-end accuracy listed in Table 1.

TABLE 1

REPORTING ACCURANCY

Measured Variable	Reported Accuracy
Space Temperature	±0.3ºF
Ducted Air	±0.3°F
Outside Air	±0.5ºF
Dew Point	±1ºF
Water Temperature	±0.3°F
Delta-T	±0.1ºF
Relative Humidity	±3% RH
Water Flow	±1.5% of rate
Airflow (terminal)	±5% of full scale (see Note 1)
Airflow (measuring stations)	±3% of full scale
Airflow (pressurized spaces)	±2% of full scale
Air Pressure (ducts)	±0.1 in. w.g.
Air Pressure (space)	±0.01 in. w.g.
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±0.5% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±25 ppm

Note 1: Accuracy applies to 10%–100% of scale

Note 2: For both absolute and differential pressure

Note 3: Not including utility-supplied meters

1.05 WARRANTY

A. Warrant that systems, subsystems, component parts and software are free from defective design, materials, and workmanship for a period of two years from the date of final acceptance, specifically including parts and labor.

B. Just before or at the end of the warranty period, update equipment firmware and software applications provided under these specifications to the latest manufacturer versions available for sale at the time.

1.06 MAINTENANCE SERVICES

A. Furnish programming and labor as required for the BOS system for a period of two (2) years after Date of Final Acceptance.

B. Provide firmware, software patch and version upgrade services for the period of two (2) years as a part of this project.
   1. At the end of the two-year period, issue a letter stating that the firmware and software residing on the system is the latest revision that would be received by new customers as if they were purchasing a new system at that time.
   2. Provide the Owner with a price to continue the software and firmware maintenance agreement in force for an extended period as requested by the Owner.

1.07 QUALITY ASSURANCE

A. References: This section contains references to the following documents that are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail:

1.	ASHRAE	Automatic Control Terminology for Heating, Ventilating, Air Conditioning
2.	ASHRAE	BACnet Standard for Automation Protocol
3.	ASME MC85.1	Terminology for Automatic Control
4.	API RP 550-85	Installation of Instruments and Control Systems
5.	ISA S5.4-76	Diagram & Instrument Loop standards
6.	ISA S5H-79	Process Instrumentation Terminology
7.	NEMA EMC1	Energy Management System Definitions
8.	NEMA ICS 1-83	General Standards for Industrial Control and Systems
9.	NEMA ICS 2-83	Industrial Control Devices, Controllers, and Assemblies
10.	C2-90	National Electrical Safety Code
11.	Title 19	State Fire Marshall Regulations
12.	70-93	National Electrical Code (NEC)
13.	NFPA 101-91	Life Safety Code
14.	Haystack	Consensus standard

B. Manufacturer: Provision of products specified in this section with minimum ten (10) year manufacturing longevity.

C. Programmer: Company specializing in programming the work of this section with minimum three (3) years of application programming experience and start-up of the distributed digital control system proposed.

D. Provide complete integration of equipment including serial digital equipment interfaces and software drivers to form a complete and comprehensive control environment.

1.08 DEFINITIONS

A. BACnet Interoperability Building Blocks (BIBB): A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.

B. BACnet/BACnet Standard: BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.

C. Control Systems Server: A computer(s) that maintain(s) the system configuration and controller program database.

D. Controller: Intelligent stand-alone control device. Controller is a generic reference to system controllers, general application controllers, and configurable application controllers.

E. Distributed Digital Control: Microprocessor-based control including Analog/Digital conversion and program logic in a stand-alone networked environment.

F. Gateway: Bi-directional protocol translator connecting control systems that use different communication protocols.

G. Local Area Network: Computer or control system communication network limited to intranets (single building or campus of buildings).

H. Master-Slave/Token Passing: RS-485 based data link protocol as defined by the BACnet standard.

I. Point-to-Point: Serial communication as defined in the BACnet standard.

J. Primary Control LAN: High speed, peer-to-peer controller LAN (Ethernet, ARCnet, other) connecting SCs and optionally AACs and ASCs. Refer to System Architecture below.

K. Protocol Implementation Conformance Statement: A written document that identifies the particular options specified by BACnet that are implemented in a device.

L. Router/Switch: A device that connects two or more networks at the network layer that can route data packets intelligently from one node to another.

M. Virtual Network: A LAN that runs over a standard Ethernet link using BACnet data packets wrapped in a cloak as if a separately wired network were applied. Used to separate control network traffic from enterprise network traffic when using the same hardwired or wireless link.

N. VPN: Virtual Private Network providing remote access to control intranets through firewalls from the internet using a secure interface.

O. Wiring: Raceway, fittings, wire, boxes and related items.

PART 2 PRODUCTS

2.01 AUTHORIZED PROVIDERS

A. Authorized software Dealers:
   1. J2 Innovations FIN Framework
   2. FIN Stack & nHAYSTACK

B. Authorized FIN Resellers & Master System Integrators:
   1. Essex Consulting Group, Inc., www.essexco.com
   2. CMS
   3. Building Control Solutions (formerly Activelogix)

C. Approved Master System Integrator (FIN) Integrators
   1. Essex Consulting Group, essexco.com
   2. CMS
   3. Building Control Solutions (formerly Activelogix)

D. Approved Analytics Software (SkySpark) Integrators
   1. Essex Consulting Group, essexco.com
   2. CMS
   3. Building Control Solutions (formerly ActiveLogix)

2.02 SYSTEM SERVER & WORKSTATION SOFTWARE

A. Provide J2 Innovations FIN Stack software and database server.

B. Provide J2 Innovations nHaystack standard tagging and modeling server.

C. Provide J2 Innovations FIN Stack graphical system program development module.

2.03 SOFTWARE PROGRAMS

A. Extend software to include new building as required for efficient operation of the functions required by this specification.

B. Provide the following basic programming features:
   1. Complete database entry.
   2. Configuration of application programs to provide the sequence of operation indicated.
   3. nHaystack tagging and modeling methodology
   4. Graphics of each system as shown on the I/O Summary Tables.
   5. Alarm limits and alarm messages for critical and non-critical alarms.

6. Schedule calendars for each controller and system
7. Configuration of reports and point summaries indicated.
8. History trends and large data analysis tools.

C. Graphical Logic Programs
1. Graphic Programming creation using a method by which a system programmer is allowed to create a sequence of operation by assembling graphic blocks that represent each of the commands necessary to complete a sequence.
2. Blocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors in addition to the more complex DDC and energy management strategies such as PID loops, optimal start/stop, optimal reset and the like.
3. Each block must be interactive, containing the programming necessary to execute the function of the device it represents.
4. Perform graphical logic programming while on screen using a pointing device. Select each block from a block library and assemble with other blocks necessary to complete the specified sequence.
5. Interconnect blocks on screen using graphic "wires" forming logical connections. Once assembled, each logical grouping of blocks and their interconnections forms a graphic function picture, which may be used to control pieces of equipment with a similar point configuration as required by the Sequence of Operation.
6. The clarity of the graphic sequence must be such that the user has the ability to verify that system programming meets the specifications without having to learn or interpret a manufacturer's unique machine programming language.
   a. The graphic programming must be self-documenting and provide the user with an understandable and exact representation of each sequence of operation.
   b. Provide a means for following the logic dynamically to verify its continuity and show where it fails to execute.
7. Provide a simulation capability with the graphic programming so the user can simulate the constructed sequence on screen before the sequences are downloaded into the controllers.
   a. Include the ability to simulate multiple graphic programs communicating with each other on a simulated network.
8. The simulation must show each output value and how it varies in relation to an artificial time scheduler.
   a. The timer may run at normal time increments, increased increments (fast motion) or decreased increments (slow motion).
9. Following is a minimum definition of the capabilities of the Graphical Programming software.
   a. Function Block (FB) - A collection of points, blocks and wires connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
   b. Logical I/O - Input/output points which shall interface with the control modules in order to read various signals and /or values or to transmit signal or values to controlled devices.
   c. Blocks - Software devices represented graphically and connected together to perform a specified sequence.
   d. Wires - Graphical elements used to form logical connections between blocks and between blocks and Logical I/O.
   e. Labels - Similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection. i.e., two points labeled "A" on a drawing are logically connected even though there is no wire between them.
   f. Parameter - A value tied to the input of a block. Each parameter will then be displayed on the resulting block parameter page and can be modified to varying

degrees based upon the appropriate password level being used by the operator. Use different parameter blocks depending on whether the parameter is digital or analog.

g. Constant - A constant shall be similar to a parameter except that it is displayed only in the graphic block file itself and will not be displayed on a parameter page. Certain coefficients which are used in various calculations always remain constant and therefore should be constants which are embedded in the program and not parameters. Different constant blocks shall be used depending on whether the constant is digital or analog.

h. Pop-ups - Pop-ups shall appear after a block has been inserted which has default parameters associated with it. Default parameter pop-ups shall contain various editable and non-editable fields and shall contain "push buttons" for the purpose of selecting default parameter settings.

i. Icon - An icon shall be graphic representation of a software program. Each graphic block has an icon associated with it to graphically describe its function.

j. Menu-bar Icon - Shall be an icon which is displayed on the menu bar on the screen which represents its associated graphic block.

D. Software Categories:

1. System management software
2. User control over system configuration at the workstation location
3. Facility management functions
4. Digital control software
5. Application software.
6. After-hours acceptance, screening and billing software.
7. Trend analysis software
8. Large data analysis software capability

E. Graphical Display Requirements

1. Display graphically in up to 256 different colors, the following system information:
   a. General area maps showing locations of controlled buildings in relation to local landmarks.
   b. Floor plan maps showing heating and cooling zones throughout the buildings in a range of colors which provide a visual display of temperature relative to their respective set points.
      1) The colors must be updated dynamically as zone comfort conditions change. Locations of space sensors shall also be shown for each zone.
      2) Provide set point adjustment and color band displays.
   c. Mechanical system graphics shall show the type of mechanical system components serving a zone through the use of a pictorial representation of components.
      1) Graphics shall provide a current status of all I/O points being controlled and applicable to each piece of equipment including analog readouts in appropriate engineering units at appropriate locations on the graphic representation.
2. Each category of software shall consist of interactive software modules. Each module shall have an associated priority level and shall execute as determined by the program controller as defined in the real time operating system.
3. The engineering workstation shall allow receipt of alarms and messages while in a functional mode other than energy management, i.e., incoming alarms shall be displayed while the operator is in a word processing, spreadsheet, or other operating mode.
   a. The system must automatically display alarms on a second screen, provide operator ability to respond to an alarm, and return to the exact position left in the previous functional mode.
   b. The building operator shall be able to communicate and direct control functions through the use of a "mouse" operator interface to monitor and control functions and sequences within the system.
4. Blocks: Programming, scheduling and set point changes shall be accessible for modification on each menu for the associated equipment. Operator shall be able to automatically download changes from the central site to the appropriate program for the

equipment being controlled. Operator shall be able to upload parameters set point information and schedules from the field modules to the central station.

a. Input Format: Operators shall be able to control system functions based on their password level. The primary operator interface shall be via a mouse type cursor controller.
b. Operator Commands: Menu driven in the graphics database.
    1) After the operator selects the desired object item or menu, the system shall display either the status of selected object item or the allowable options available.
    2) Upon entry of a command to the point or points desired as described above, the system shall, before performing a command, respond with an echo of the request.
    3) This echo feedback shall include the command requested and any entered data.
    4) System shall include error monitoring software for user's input error.
c. Output Format: Operate on a System Format basis, regardless of the manner or hardware configuration in which the data is acquired.
    1) A "system" shall consist of a logical grouping of data points, related to a piece of mechanical equipment, an energy distribution system, or an architectural service area.
    2) For example, in some cases, it may be desired to display, as a single system, a space temperature with its associated air handling unit, and in other cases to display all space temperatures on a floor or in a building.
    3) The system shall allow such determinations to be made without regard to the physical hardware locations of a point or group of points.
    4) Likewise, the system shall accommodate future changes of system grouping and operations without field hardware changes.

5. Displays and logs shall contain a header line indicating date, day-of-week, and time. Output displays or logs of a point or group of points shall contain, as a minimum, the following information:
    a. Graphic presentation of the System
    b. User name of point
    c. Point descriptor (Haystack convention)
    d. Current value/status
    e. Associated engineering units
    f. Alarm description
    g. Trend description
6. User names, point descriptors, and engineering units shall be operator definable on a per point basis.
7. Temperature Set points: Utilize a contiguous band of colors each corresponding to actual zone temperatures relative to the desired heating and cooling set points.
    a. The ideal temperature shall be shown as a green color band. This color band corresponds to the dead-band between the onset of mechanical heating or cooling.
        1) Show temperatures slightly warmer than ideal in yellow and even warmer temperature in orange.
        2) Temperatures slightly cooler than ideal shall be light blue
        3) Even cooler temperatures shall be dark blue.
        4) Alarm colors shall be in red.
    b. The system shall be capable of utilizing the operator mouse to change individual zone temperature bar and by pressing a button, and by moving the mouse cursor to an increased or decreased temperature set point within that zone.
    c. The system shall also be capable of utilizing the mouse or a conventional keyboard to change a numeric temperature set point value instead of utilizing the graphic temperature bar. The floor plan graphic shall then be able to change colors on a zone by zone basis to reflect the actual temperature in each zone relative to the changed desired heating or cooling set point.

d. Provide capability of globally changing set points and other parameters as needed.
e. Graphic Structure: The intent of the graphics is to ensure the operator is always aware of his position within the system and how to logically and intuitively progress through the graphical hierarchy to select desired graphic or other source of information. Provide the operator with the capability of returning to a previous graphic by pointing to a graphic tab then pushing a single button. Program the system to provide a separate color graphic for each piece of equipment monitored or controlled including:
    1) Each building
    2) Each floor and zone controlled
    3) Each equipment unit and terminal
    4) Each schedule
    5) Each trend
    6) Each report
    7) Each Graphical Software Program
f. Passwords: User Access Restriction.
    1) Operator sign-on shall require an assignable password.
    2) Each operator can be assigned to one of ten levels of system access.

F. User Control over System Configuration
1. Database Creation and Modification. Changes shall be made utilizing standard procedures while the system is on-line and operational. The system shall allow changes to be made at the local site through a portable communicating device and at the central site.
2. The system shall permit the operator to perform the following:
    a. Add and delete points
    b. Modify point parameters
    c. Attach nHaystack attributes
    d. Create and modify control sequences and programs
    e. Set PID loop parameters
    f. Reconfigure application programs
    g. Add and/or modify graphics
    h. Save data changes to the system server-workstation
3. Data points within the database shall be completely accessible as independent or dependent variables for custom programming, calculation, interlocking or manipulation.
4. Graphics Construction: Permit the easy construction of infinitely variable shapes and sizes through the use of the mouse pointing device. A selection of 256 colors and various fill textures, line types and text styles shall all be accessible through the use of the mouse interface. The software shall resemble many of the computer aided design programs currently available and allow graphics to be easily moved, edited, added or deleted. Graphics software shall be fully implemented and operational to accomplish the following:
    a. Create a new graphic picture
    b. Modify a portion of a graphic picture
    c. Delete a graphic picture, or any portion thereof
    d. Call up a graphic picture
    e. Cancel the display of a graphic picture
    f. Assign conditions which automatically initiate the display
    g. Overlay alphanumeric and graphics
    h. Save the graphic picture
    i. Display latest process data fully integrated with the graphic display
    j. Display Live Graphical Software Programs
5. The central station must be able to generate standard ASCII file formats to allow use with third-party software to generate and store owner-designed reports.

G. Facility Management Functions
1. Trend Logging

a. Trend and display either numerically or graphically analog or digital physical points or calculated points or output from blocks in the Graphics Programs.
b. Simultaneously display four (4) values within a function block of programming showing the most recent two hundred and eighty eight (288) samples. Sample intervals shall be as small as one (1) second.
c. Each trended point shall be trended at a different trend interval if desired. When multiple points are selected for display having different trend intervals, automatically scale the axis.
d. Each module shall be capable of automatically uploading on a daily basis all accumulated trend data to the central station for permanent storage on hard disk.

2. Trend Historian (TH)
   a. Provide the ability to set up a continuous trend of a point or points as described above, for a limitless period of time.
   b. Points assigned to the TH will automatically upload to the central database, the trend information in groups of the most recent 288 samples. This will continue as long as the point is assigned.
   c. The system operator shall be able to simultaneously display four (4) values being trended by the TH.
   d. The operator shall be able to move back in time by clicking with the mouse on a button marked "back", or forward in time by clicking on a button marked "forward". The operator shall also have the option of typing in a date in the approximate location that will automatically display the trend information for that time period.
3. Run Time
   a. Provide run time information for digital output and input points for all modules on command from the operator. Maximum run time limits shall be operator definable and shall automatically issue a printed message when the run time maximum is exceeded. The operator shall be able to reset the run time accumulator.
   b. Run time hours and start time date shall be retained in non-volatile module memory.
   c. Each module shall be capable of automatically uploading all accumulated data to the central station for permanent storage on hard disk.
4. Alarm Conditions and Maintenance Messages
   a. Allow receipt of alarms and messages while in a functional mode other than energy management; e.g., display incoming alarms while the operator is utilizing a word processing program and allow the operator to automatically return to word processing after the alarm is received.
   b. Distinguish between alarms and messages with alarms having a higher priority.
   c. Use the Internet to page three locations to deliver alarm messages. Determination if alarms and/or messages are based on temperature, equipment status or off-normal reporting is user assignable.
   d. Print maintenance messages when run time accumulation maximum limits are exceeded.
   e. Provide operator definable alarm and message text strings. Store at least 2,000 alarm messages and 2,000 maintenance messages of any length for use by the system. Generic messages linked to multiple points count as one.
   f. In the event the workstation is powered down, store alarms in the field modules until the workstation can be restored. Deliver alarms and data register information to multiple workstations via the network.
   g. Transfer alarms and their disposition to the database at the designated workstation or server for archiving.
5. Reports and Archiving
   a. The field modules shall be capable of uploading the central database to automatically upload current and accumulated data. This shall be delivered to the central station for printing and/or permanent storage. The system shall further be capable of transferring local information onto DVD ROM or Memory Stick for remote site archiving.

b. Report and archive the following information as a minimum:
   1) Outside air temperature history and degree-day history:
   2) Electrical demand and usage history
   3) Trended points
   4) Alarms and messages
   5) Equipment runtime information
c. Provide the following additional reports for which archiving is not applicable:
   1) Points summary
   2) Equipment operating schedules
   3) Print graphic screens
d. Provide points summaries on a hierarchical basis. e.g. Only the points associated with a particular graphic shall be selectable and printed.
   1) For example, if the operator is viewing an air handling unit (AHU), he may request a point summary at this level and receive only the points associated with that AHU.
   2) If the building is being viewed and a point summary is selected, all building points will be listed. Similarly, print building operating schedules pertinent to the graphic level being viewed.
   3) If a zone or tenant zone group is being viewed on the graphic display, then show the building operating schedules for the zone or tenant zone group.
   4) If the entire building graphic is being viewed, show schedules at the building level.
e. View system reports at the operator's workstation and print them at the operator's discretion.

6. Custom Reports and Logs
   a. Provide for user created custom report and logging formats via a text editor program.
   b. User define a system report with desired point data from the field, insert the data in the custom report format, store the report on workstation hard disk as well as have it print out on the system and/or remote printers.
   c. Custom report generation can be initiated either manually, based on a field occurrence or based on time, or any combination.
7. Dynamic Live Graphical Software Displays
   a. Display the Live Graphic Function Block created by software programs within the system.
   b. The Live Graphic Function Block displays real and dynamically updated data for each micro-block in the Graphic Function Block software program without degradation of system performance.
   c. Report discrepancies between parameter information stored in the modules and the parameter information stored in the host workstation.
   d. Allow the operator to edit a Graphic Function Block's operating parameters from the Live Graphic Function Block screen without having to go to any other screen.
   e. Download changes to operating parameters from the Live Graphic Function Block screen to the database and to the involved controller.

PART 3 EXECUTION

3.01 ADJUSTMENTS

A. Adjust controls and equipment to maintain the conditions indicated, to perform and to operate in the sequences specified.

B. Adjust values after installation for optimal operation and intuitive manner.

3.02 WORKSTATION DATABASE AND GRAPHICS GENERATION

A. Database: Prepare and enter database and complete the programming for automatic control functions for the owner as called for in the Sequence of Operation and Control Drawings.

B. Color Graphics: Create and enter color graphics for each mechanical system including dynamic point database required for each input/output required.
   1. Color graphic screens shall be created to match plant P&I diagrams and AHU airflow detail as shown on design Drawings.
   2. Generate color graphics showing system schematics for each building and for its respective heating and cooling plants.

3.03 SYSTEM ACCEPTANCE

A. Functional Tests: Controllers shall be tested and documented via a functional test as follows:
   1. An output channel will be commanded (on/off, stop/start, adjust, status) and operation verified.
   2. An analog input channel will be verified for proper sensor location and signal operation by opening and closing its circuit at the sensor end and then by verifying with a calibration instrument.
   3. A digital input channel will be verified by changing the state of the field device and observing the appropriate change of displayed value.
   4. If a point should fail testing, perform necessary repair action and retest failed point, and verify interlocked points.
   5. Stable automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
   6. Selected time and set point schedules shall be verified by changing the schedule and observing the correct response at the controlled outputs.

B. Field Acceptance Tests: Upon completion of Continuity Tests, Functional Tests and 72 hours of continuous systems operation, and before final acceptance of work, test the controlled systems in operation to demonstrate compliance with the Contract Documents.
   1. Notify the Owner a minimum of 15 working days prior to the date testing is to commence.
   2. Test and document controls and systems through each sequence of operation, including simulation of each season insofar as possible.
   3. Test and document safety controls to demonstrate performance of required function.
   4. Adjust or repair defective or malfunctioning DDC equipment or replace with new equipment.
   5. Repeat tests to demonstrate compliance with the Contract Documents.
   6. Submit Field Acceptance Test procedure to the Owner at least 30 days before testing for approval.
   7. Test procedure shall include interfaces required by various trades to complete Field Acceptance Testing.

C. Workstation Test Procedures: The system workstation test procedures shall be as follows:
   1. Fast and accurate communication with typical DDC zone and local controllers will be demonstrated.
   2. Operator commands will be explained and demonstrated.
   3. Selected control sequences shall be demonstrated for proper operation.
   4. Demonstrate selected system reports and logs at the System Workstation.
   5. Demonstrate correct system start-up and shutdown procedures.
   6. Demonstrate that controllers can operate in a stand-alone mode.
   7. Demonstrate color graphics for each mechanical system.

D. Provide a commissioning report to the Owner detailing the dated, times, and person(s) performing the start-up. This report shall detail when and who performed the individual processes stated previously.

3.04 TRAINING

A. Provide a training outline to the Owner prior to scheduling training sessions.

B. Training sessions shall be provided for the Owner’s personnel by FIN certified control system engineers, programmers, and technicians.

C. Conduct training courses for the designated Owner's personnel in the maintenance and operation of the control system.
   1. One class shall be given upon system acceptance and the other approximately six months after the warranty commences.

D. Include instruction on specific systems and instructions for operating the installed system to include as a minimum:
   1. Central Plant and TES system overview.
   2. Sequence of operation.
   3. Operation of control system.
   4. Function of each component.
   5. System operating procedures.
   6. Programming procedures.
   7. Maintenance procedures.
   8. AST – Alarming, Scheduling and Trending.
   9. Emergency restart and local override.

E. In addition to the training required above, make factory training courses routinely available (including those conducted for the manufacturer's own engineers, technicians and representatives) to the Owner's personnel. Evidence of the routine availability of such courses shall be presented with the submittals.

F. Provide telephone support and answer questions throughout the two-year warranty period.

END OF SECTION

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Electrical superintendent requirements.
   2. Electrical equipment coordination and installation.
   3. Division of Work between trades
   4. Common electrical installation requirements.

1.02 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.03 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. To allow connecting raceways, cables, wireways, cable trays, and busways to be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers, junction boxes, or other equipment requiring access which is located above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Contractor shall locate access doors where any valves, unions or equipment/devices requiring access for servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings, unless otherwise noted. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arms length. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Panels."

D. Coordinate meter location(s) and conduit(s) from transformer(s) to meter(s) with local utility company.
   1. Provide conduit(s) per utility company requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. All electrical materials, devices, appliances and equipment for the Work shall be evaluated for safety and suitability for intended use. Evaluation shall be conducted by a Nationally Recognized Testing Laboratory (NRTL), and all markings, labels and other identification

required by those listings and certifications shall be provided on those materials, devices, appliances, and equipment. If provided material is not labeled, Contractor shall provide third-party listing at no additional cost.

1. Third Party Agencies shall be amongst those accredited by the NCBCC (North Carolina Building Code Council) to Label Electrical and Mechanical Equipment. Refer to NC Office of State Fire Marshal website for current list of acceptable third-party agencies.
   a. https://www.ncosfm.gov/third-party-testing-agencies

PART 3 EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

F. Contractor shall submit documentation to the Engineer listing the manufacturer’s torque recommendations at all terminals and verifying the torque completed by the electrician.

3.02 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Firestopping."

END OF SECTION

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

1.02 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For testing agency.

C. Field quality-control test reports: From a qualified testing and inspecting agency engaged by Contractor.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.05 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 PRODUCTS

2.01 CONDUCTORS AND CABLES

A. 600-Volt Building Wire Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. General Cable Corporation.
   2. Southwire Company.
   3. Encore.
   4. Okanite
   5. Tyco

B. Special Systems Wire Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Belden Cable
   2. Tyco Thermal Controls (fire alarm cable)

C. Copper Conductors: Comply with NEMA WC 70. Aluminum shall not be used in any case.

D. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN

E. Conductors for 2-hour fire rated installation: Copper, Type MI insulation in accordance with UL 44.
   1. For use in wet locations to 75^0 C and in dry locations to 90^0.
   2. Low temperature rated -40^0 C (UL) -25^0 C (CSA).
   3. 2-hour fire rated per UL 2196/ULC S139 (1850^0 F with hose stream)
   4. Low toxicity index per NES-713.
   5. Fully compliant with NEC Articles 695 and 700 when installed in conduit and in accordance with manufacturer's installation procedures and system listings.

F. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC and Type SO with ground wire.

G. Conductor sizes: Minimum conductor size shall be #12 for feeder and branch circuits. Maximum conductor size shall be 500 kcmil. per 2020 SCO Electrical Guidelines and Policies.

2.02 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.
   6. Ilsco
   7. Thomas-Betts
   8. Ideal

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.03 CONDUCTOR AND CABLE LUBRICANT

A. Manufacturers:
   1. American Polywater Corporation
   2. Ideal Industries
   3. 3M Company

B. The cable pulling lubricant GEL shall be compatible with all cable jackets. The lubricant GEL shall be UL or CSA listed and water soluble, non-toxic and environmentally safe.

2.04 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section " Firestopping."

2.05 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex Co.
   4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
   2. Pressure Plates: Plastic. Include two for each sealing element.
   3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THWN-2, 90°C Wet rating single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SOJ, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. Class 1 Control Circuits: Type THHN-THWN, in raceway.

J. Class 2 Control Circuits: Type THHN-THWN, in raceway.

K. Fire Alarm Signaling and Notification Circuits: Refer to specifications for fire alarm system.

L. Provide UL Listed, 2-hour fire resistant cables to maintain circuit integrity and installed in a metallic raceway per the cable manufacturer's recommendation. The 2- hour rating shall be for all emergency feeders installed in spaces or areas not protected by a fire suppression system as follows:
   1. The Contractor shall verify requirements with the Authority Having Jurisdiction for the specific building construction on this project prior to installation of emergency feeders.
      a. Obtain written permission from the Authority Having Jurisdiction to use any non-fire rated emergency feeder in spaces and/or areas not protected by an approved fire suppression system.
   2. Areas not covered by sprinklers shall include, but are not limited to, above a lay-in or sheetrock ceiling, in un-rated shafts (unless sprinkler heads are installed).

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Unless specifically noted on the drawings, all wiring shall be installed in a raceway.

B. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

C. Surface mount devices only where specifically shown on the plans. Obtain written permission from the Engineer for all other surface mounting locations that are not specifically shown on the plans.

D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

F. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

G. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

H. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

I. Where the conductor length from the panel to the first outlet on a 277 volt circuit exceeds 125 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

J. Where the conductor length from the panel to the first outlet on a 120 volt circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

K. Install no more than 3 phase wires in any feeder or branch circuit conduit.

L. Install a dedicated neutral conductor for each single phase 277-volt or 120-volt circuit.

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Joints in solid conductors shall be spliced using Ideal “wirenuts”, 3M Company “Scotchlock” in junction boxes, outlet boxes and lighting fixtures.
   1. “Sta-kon” or other permanent type crimp connectors shall not be used for branch circuit connections.

D. Joints in stranded conductors shall be spliced by approved mechanical connectors and electrical vinyl tape.
   1. Solderless mechanical connectors for splices and taps, provided with U/L-approved insulating covers, may be used instead of mechanical connectors plus tape.

E. Conductors, in all cases, shall be continuous from outlet to outlet and no splicing shall be made except within outlet or junction boxes, troughs and gutters.

3.05 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
   1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.

2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed unless seismic criteria require different clearance.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.06 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Firestopping."

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Prior to energizing feeders, sub-feeders and service conductor, cables shall be tested for electrical continuity and short circuits. A copy of these tests shall be sent to the engineer of record, and the owner.
3. All current carrying phase conductors and neutrals shall be tested as installed, and before connections are made, for insulation resistance and accidental grounds. This shall be done with a DC megger. The procedures listed below shall be followed:
a. Three-phase conductor installations:
1) For each phase conductor, ground all other conductors, shields and metal conduit as applicable.

2) Apply test voltage between tested conductor and ground for sixty seconds. Repeat this procedure for other phase conductors.
3) Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG wire and smaller, 250,000 ohms or more for #4 AWG wire or larger, between conductors and between conductor and ground.

b. Single-phase conductor installations:
1) Ground the neutral conductor, neutral shield and metal conduit as applicable.
2) Apply test voltage between phase conductor and ground for sixty seconds.
3) Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG wire and smaller, 250,000 ohms or more for #4 AWG wire or larger, between the phase conductor and ground.

c. After all fixtures, devices and equipment are installed and all connections completed to each panel, the contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and the grounded enclosure.
1) Whenever this reading is less than 250,000 ohms, the contractor shall disconnect the branch circuit neutral wires from this neutral bar. The contractor shall then test each one separately to the panel until the low reading is found.
2) The contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.

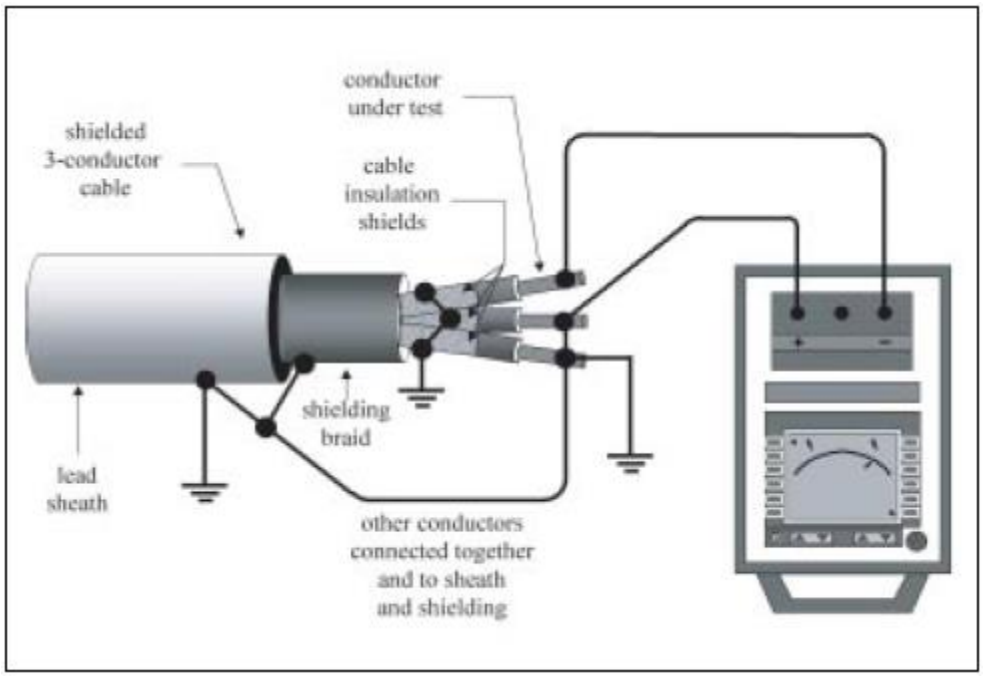
d. At final inspection, the contractor shall furnish a megger and show the engineers and, when applicable, the State Construction Office representatives that the panels comply with the above requirements.
1) The contractor shall also furnish a hook-on type ammeter and voltmeter to take current and voltage readings as directed by the representatives.

4. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Test Reports: Prepare a written report to record the following and complete the form at the end of this section:
1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

Figure1: Example conductor-megger setup.



REPORT OF CABLE MEGGER TESTING

TESTING COMPANY: _____

DATE OF TEST: _____

CLIENT/LOCATION: _____

MANUFACTURER AND TYPE OF CABLE: _____

VOLTAGE RATING OF CABLES: _____

TEST EQUIPMENT MFG./MODEL: _____

TEST VOLTAGE (IN VDC): _____

TEST RESULTS (IN MEGA-OHMS):

PANEL/CABLES TESTED	CABLES A-G	CABLES B-G	CABLES C-G	PANEL NEUTRAL TO ENCLOSURE

WEATHER CONDITIONS:

_____

_____

COMMENTS:_____

_____

TESTER'S SIGNATURE: _____

CONTRACTOR'S LICENSE #: _____

END OF SECTION

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding points for chilled water piping, domestic water piping, fire protection piping and natural gas piping.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Qualification Data: For Exothermic-welding personnel.

E. Field quality-control test reports. Submit written test reports to include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
   1. Instructions for periodic testing and inspection of grounding features at test wells based on NETA MTS.
      a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
      b. Include recommended testing intervals.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with UL 467 for grounding and bonding materials and equipment.

D. Personnel performing Exothermic-welding must be certified by the manufacturer whose equipment will be utilized on this project and must provide a certificate indicating the manufacturer who provided the training and the date of the training.

PART 2 PRODUCTS

2.01 CONDUCTORS

A. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.02 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
   1. Provide correct mold for type and size of conductor and termination type.

2.03 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad, 3/4 inch in diameter and 10-feet long and shall be copper-clad steel construction.
   1. Inspection Wells: Provide inspection well for each grounding electrode installed as detailed on the drawings.

PART 3 EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install a continuous bare copper conductor, No. 2/0 AWG minimum unless show otherwise on the drawings.
   1. Bury at least 24 inches below grade.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
   2. Provide a main ground bus for the service as shown on the drawings: ¾-inch minimum thick x 24-inch minimum length. Increase size if necessary to accommodate the required exothermic terminations.
   3. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

D. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Exothermic-welded connectors except and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Exothermic weld.
   4. Connections to Structural Steel: Exothermic-welded connectors.
   5. Connections to ground bus: Exothermic-welded

3.02 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install four ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation. Refer to details on the drawings.

3.03 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders, branch circuits, raceways, and cables.

B. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system ground bus to each service location, terminal cabinet, wiring closet, and central equipment location.
   1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
   2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

C. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.04 INSTALLATION

A. Grounding electrode conductors #4 AWG and larger shall be installed in a raceway system.

B. Wherever grounding electrode conductors are connected/bonded to wall mounted grounding busses, all conductors shall be identified with black phenolic identification labels having ¼" high white letters indicating the equipment where the grounding electrode conductor originates from. Labels shall be wire-tied to the grounding electrode conductors at the point where the conductor is connected/bonded to the bus. The following areas apply:
   1. Main Electric room grounding bus.
   2. Satellite electric rooms grounding busses.
   3. Emergency electric rooms grounding busses.
   4. Telecommunications rooms grounding busses.

C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
   2. Provide test/inspection wells for each ground rod installed. Refer to drawings for details.

3. For each electrical service on the project install at three rods spaced at least 20-ft. from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor and to the main ground bar. Refer to drawings for details.

E. Test Wells: Ground rod driven through drilled hole in bottom of Test/Inspection well as indicated on the drawings and shall be at least 12 inches deep, with cover.
1. Test Wells: Install test well for each Ground Rod unless otherwise indicated. Set top of test well flush with finished grade or floor.

F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
4. Bond cable trays and/or cable ladder sections at all section joints, tees, radius, waterfalls and 4-way intersections.

G. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Connect within 5'-0" of where pipe enters building. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Chilled Water, Hot Water and Steam Piping: Where chilled water piping and/or hot water piping and/or steam piping enter the building install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to metal pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Connect within 5'-0" of where pipe enters building. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
4. Gas Piping: Where gas is utilized for connected electrical equipment within the building having the potential of energizing the gas piping due to a failure of insulation of the connected electrical equipment the gas piping shall be bonded to the grounding system. The bonding shall occur between the gas shutoff valve and where the gas piping enters the building or in the case of underground piping entering the building below grade the gas piping shall be bonded within 5-ft of where it enters the building.

H. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.05 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.

3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Non-contact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Connections at Test Wells: Use Exothermic-welded connections between conductors and ground rods.

F. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.06 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal and at individual ground rods. Make tests at ground rods before any conductors are connected.
   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.
3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

3.07 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.02 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Nonmetallic slotted channel systems. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

D. Provide dimensioned layout drawing(s) of main electrical room, emergency electric room, and electrical closets prior to commencing work in that room. The scaled drawing(s) shall indicate actual dimensions of proposed equipment, front elevations, and access door swings. Minimum scale factor shall be ¼” = 1’-0”.
   1. Coordinate the installation drawings with all other trades to assure proper and conflict free installation of electrical systems and components.
   2. Submit drawings to the Engineer for review prior to commencing the installation of any electrical equipment.

1.05 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.06 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

C. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

D. Coordinate electrical service connections to components furnished by utility companies.
   1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
   2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

E. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 08 Section "Access Doors and Panels."

F. Coordinate installation locations of electrical switchboards, panelboards, disconnect switches, circuit breaker enclosures, control enclosures, motor control centers, raceways, lighting fixtures, junction and pull boxes with all mechanical, plumbing and fire protection trades prior to installation of equipment and systems.
   1. Provide dimensioned layout drawing(s) of the proposed locations of all switchboards, panelboards, disconnect switches, circuit breaker enclosures, control enclosures, motor control centers, raceways, lighting fixtures, junction/pull boxes larger than 6” x 6” x 4” and conduit routing of all conduits over 2” diameter. The scaled drawing(s) shall indicate actual dimensions of proposed equipment, front elevations, and access door swings. Minimum scale factor shall be 1/8”= 1’-0”.
   2. Coordinate the installation drawings with all other trades to assure proper and conflict free installation of electrical systems and components.
   3. Submit drawings to the Engineer for review prior to commencing the installation of any electrical equipment.
   4. Provide code required access and clearances to all equipment and sufficient access for maintenance.

G. All individual motor starters for mechanical equipment (fans, pumps, etc.) shall be furnished and installed under Division 23 unless indicated otherwise.

H. Under Division 26, power wiring shall be provided up to a termination point consisting of a junction box, trough, starter or disconnect switch. Line side terminations shall be provided under Division 26. Wiring from the termination point to the mechanical equipment, including final connections, shall be provided under Division 22 or 23.

PART 2 PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.
      c. ERICO International Corporation.
      d. GS Metals Corp.
      e. Thomas & Betts Corporation.
      f. Unistrut; Tyco International, Ltd.

g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
4. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. Fabco Plastics Wholesale Limited.
   d. Seasafe, Inc.
2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.
2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Light Steel: Sheet metal screws.
   5. Conduits installed on the interior or exterior building walls shall be spaced off the wall surface a minimum of ¼-inch using “clamp-backs” or strut.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes raceways, fittings, poke through devices, boxes for in slab boxes.

1.02 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. FMC: Flexible metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. NBR: Acrylonitrile-butadiene rubber.

H. RNC: Rigid nonmetallic conduit.

1.03 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
   1. Custom enclosures and cabinets.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 PRODUCTS

2.01 METAL CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Tube & Conduit; a Tyco International Ltd. Co.
   2. Anamet Electrical, Inc.; Anaconda Metal Hose.
   3. Maverick Tube Corporation.
   4. O-Z Gedney; a unit of General Signal.
   5. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. Aluminum Rigid Conduit: ANSI C80.5.

D. IMC: ANSI C80.6

E. EMT: ANSI C80.3.

F. LFMC: Flexible steel conduit with PVC jacket.

G. FMC: Zinc-coated steel, complying with UL.

H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Fittings for EMT: Plated-steel hexagonal compression type or double steel set-screw fittings. Cast, pot metal, or crimp type fittings are not acceptable.
   a. Box connectors shall be insulated throat type.
2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

I. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.02 NONMETALLIC CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. LFNC: UL 1660.

D. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

E. Fittings for LFNC: UL 514B.

2.03 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.
4. Austin Electrical Enclosures.

B. Sheet metal sized and shaped as indicated, NEMA 250 Type 1, unless otherwise noted.

C. Fittings and Accessories: Include couplings; offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

E. Finish: Metal Manufacturer’s standard enamel finish.

2.04 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Crouse-Hinds.
2. Hoffman.
3. RACO; a Hubbell Company.
4. Thomas & Betts Corporation.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.

E. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch.
   1. Metal Enclosures: Steel, finished with manufacturer's standard enamel.

F. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Metal barriers to separate wiring of different systems and voltage.

PART 3 EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
   1. Exposed Conduit: Rigid steel conduit.
   2. Concealed Conduit, Aboveground: Rigid steel conduit.
   3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
   5. Underground Conduit: RNC, Type EPC-40-PVC where concrete encased and Type EPC 80 PVC where direct buried.

B. Indoors: Apply raceway products as specified below, unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed and Subject to Physical Damage: Rigid steel conduit.
      a. Locations less than 8 feet above finished floor.
      b. Stub-ups to above suspended ceilings.
   3. Concealed in Ceilings or Interior Walls and Partitions: EMT.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
   5. Damp or Wet Locations: Rigid steel conduit.
   6. Boxes and Enclosures: NEMA 250, Type 1. Use NEMA 250, Type 4, stainless steel in wet or damp locations.
   7. Under slab: RNC Type EPC-40-PVC.
   8. Raceway Color Coding: Apply color coding to both concealed raceway in all locations and exposed raceway in non-finished areas.
      a. 120/208V Raceway: EMT raceway containing 120/208V wiring shall have a factory applied black color finish.
         1) Labels shall be located 15' apart. Label text "120/208V" white text on black label.
      b. 277/480V Raceway: EMT raceway containing 277/480V wiring shall have a factory applied orange color finish.
         1) Labels shall be located 15' apart. Label text "277/480V" black text on orange label.
      c. Fire Alarm Raceway: EMT raceway containing fire alarm wiring shall have a factory applied red color finish.
         1) Labels shall be located 15' apart. Label text "FA" black text on red label.
      d. Telecommunications/Data and Security Raceway: EMT raceway containing telecom/data or security wiring shall have a factory applied blue color finish.
         1) Labels shall be located 15' apart. Label text "Tele/Data" white text on blue label.
      e. BAS Controls Raceway: EMT raceway containing BAS control wiring shall have a factory applied yellow color finish.
         1) Labels shall be located 15' apart. Label text "BAS" black text on yellow label.

f. Emergency System Raceway: EMT raceway containing emergency system wiring shall have a factory applied green finish.
g. Rigid steel conduit used for the above systems shall be field painted to match corresponding EMT finish.
h. For exposed raceways in finished areas with exposed structure, match ceiling paint.
i. Label in-wall conduit at stub up where conduit extends above walls/turns into ceiling. \
j. All above ceiling conduit shall be labelled 15' on center. Junction box covers shall be painted and labeled.
k. Label Manufacturers:
    1) Brady ID Arrow and Pipe Banding Tape + Brady Pipe Markers.
    2) Marking Services Inc.
    3) Pipe Markers.

C. Minimum Raceway Size: 3/4-inch trade size for power, 1 ¼" for Data and 1 ¼" for Audio/Visual.

3.02 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

C. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

D. Avoid exposed conduit runs. Conduit may be run exposed where it is impractical or impossible to conceal and where specific approval is obtained.
1. In rooms with exposed structural ceilings, route conduit as high as possible to maintain maximum clear usable space for occupants. Where junction boxes are required, drop conduit down to a junction box mounted below other systems to ensure accessibility.

E. EMT conduit provide below roof deck shall be installed a minimum of 1-1/2" away from the deck to avoid screws penetrating the EMT conduit during reroofing.

F. Conduit (whether exposed or concealed) shall be neatly installed, grouped and parallel to or at right angles to beams, walls, and floors of the building.

G. Embedded raceways within concrete slabs shall not be permitted due to the potential practice of 'blind' drilling floor and elevated slabs for the purpose of installing fastening devices.
1. Raceways shall be routed under slab on grade or suspended to the bottom of the elevated slab supporting structure.
2. Bend conduit up sufficiently to enter floor boxes at Knock-outs.

H. Raceway Terminations at all conduit ends entering junction boxes, panel enclosures, switchboards and control enclosures:
1. Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
1. Where otherwise required by NFPA 70.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

J. For floor boxes installed in slab-on grade concrete provide concrete 'pour-pans' made specifically for the floor boxes being installed.
1. Install under the floor box.

K. For floor boxes installed in fire rated elevated concrete slabs provide UL fire rated assembly and/or product to the bottom of the floor box where the floor penetration occurs to maintain the fire rating of the floor per the structural design.

L. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

END OF SECTION

SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks.
   2. Handholes and boxes.

1.02 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.03 SUBMITTALS

A. Product Data: For the following:
   1. Duct-bank materials, including separators and miscellaneous components.
   2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   3. Accessories for manholes, handholes, boxes, and other utility structures.
   4. Warning tape.

B. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Cover design.
   3. Grounding details.
   4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

C. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   2. Drawings shall be signed and sealed by a qualified professional engineer.

D. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

E. Qualification Data: For professional engineer and testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

1.04 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Electrical Components, Devices, and Accessories (Including Ducts for Communications and Telephone Service): Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.06 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Cable-support stanchions, arms, insulators and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.07 COORDINATION

A. Coordinate layout and installation of ducts, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Engineer.

PART 2 PRODUCTS

2.01 CONDUIT

A. RNC: Schedule 40 PVC. Comply with NEMA TC 2, NEMA TC-18 and UL 651.

2.02 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.
12. Southern Pipe, Inc.
13. Queen City Plastics, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 2, NEMA TC-18, NEMA Type EPC-40-PVC (Schedule 40 PVC), UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

C. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."
3. Duct Sealing Compound: Nonhardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 34 deg F, withstands temperature of 300 deg F without slump, and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and the common metals.

2.03 CONSTRUCTION MATERIALS

A. Mortar: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.

B. Concrete: Use 3000-psi- minimum, 28-day compressive strength and 3/8-inch maximum aggregate size. Concrete and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."

PART 3 EXECUTION

3.01 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 V and Less: RNC**,** NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

3.02 EARTHWORK

A. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated.

B. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work.

3.03 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

E. Pulling Cord: Install 100-lbf- test nylon cord in ducts, including spares.

F. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.
3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on indoor or on outdoor concrete bases, extend rigid steel conduit vertically into the equipment. Install insulated grounding bushings on terminations at equipment.
9. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and direct buried duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

G. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.
    1. Whenever electrical duct banks are to be provided by other divisions, provide that division with line markers for installation by them.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
    1. Demonstrate compliance with requirements on completion of installation of underground ducts and utility structures.
    2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.05 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION

SECTION 26 05 50 – VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.02 DEFINITIONS

A. BAS: Building Automation System.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. LCD: Liquid-crystal display.

F. LED: Light-emitting diode.

G. OCPD: Overcurrent protective device.

H. PID: Control action, proportional plus integral plus derivative.

I. RFI: Radio-frequency interference.

J. VFD: Variable-frequency drive.

1.03 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.
   1. Include dimensions and finishes for VFDs.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFD indicated.
   1. Include mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Variable frequency drives shall be included in the development of the Coordination and Installation Drawings, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFDs.
   2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Product Certificates: For each VFD from manufacturer.

C. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

D. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.
   1. Include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
c. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.06 DELIVERY, STORAGE, AND HANDLING

A. VFDs should be delivered, stored and handled in a manner that protects them from damage, moisture, dirt and intrusion of foreign materials.

B. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Maximum ambient temperature for storage shall be -40 to 120 degrees Fahrenheit.

1.07 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
3. Auxiliary Contacts: Furnish two spares for each size and type of magnetic controller installed.
4. Power contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.08 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Three years from date of Final Acceptance.

1.09 ALTERNATES

A. Work of this Section is affected by an Alternate. Refer to Section 01 23 00 – Alternates.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Inc.
2. Danfoss Inc.
3. Yaskawa Electric America, Inc.

2.02 SYSTEM DESCRIPTION

A. General Requirements for VFDs:
1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Variable torque.

C. VFD Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage (not applicable to fan arrays).
1. For fan arrays, output rating shall match fan array motor selection.

F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F. Operating up to 122 deg F shall be possible with 10 percent de-rating if required.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Output Carrier Frequency: Selectable; 0.5 to 12 kHz.
14. Stop Modes: Programmable; includes fast, free-wheel, and dc coast or ramp to stop.

G. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 4:1 speed range.
1. Signal: Electrical.

H. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 110 percent of maximum rating.

I. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection (drive and bypass mode).
9. Short-circuit protection.
10. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt five restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

L. Integral Input Disconnecting Means and OCPD:
   1. VFDs With a Bypass System:
      a. UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
      b. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.
   2. VFDs Without a Bypass System:
      a. NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.
      b. Disconnect Rating: Not less than 115 percent of VFD input current rating.

2.03 CONTROLS AND INDICATION

A. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

B. Historical Logging Information and Displays:
   1. Real-time clock with current time and date and battery backup.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last three faults with time and date stamp for each.

C. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
   1. Output frequency (Hz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (V dc).
   9. Set point frequency (Hz).
   10. Motor output voltage (V ac).

D. Control Signal Interfaces:
   1. Electric Input Signal Interface:
      a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
      b. A minimum of six multifunction programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS system for HVAC or other control systems:
      a. 0- to 10-V dc.
      b. 4- to 20-mA dc.
      c. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
   a. Output frequency (Hz).
   b. Output current (load).
   c. DC-link voltage (V dc).
   d. Motor torque (percent).
   e. Motor speed (rpm).
   f. Set point frequency (Hz).
4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

E. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
   1. Number of Loops: Two.

F. Interface with BAS System for HVAC: Factory-installed hardware and software shall interface with BAS system for HVAC to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained within VFD's nonvolatile memory.
   1. Hardwired Points:
      a. Monitoring: On-off status.
      b. Control: On-off operation.
   2. Communication Interface: The standard protocols shall be BACnet IP. Communication shall interface with BAS system for remotely control and monitor from an operator work-station. Control features and monitoring points displayed locally at control panel shall be available through the BAS system and mapped to graphical user interfaces.

2.04 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations. Provide minimum 5 percent impedance AC line reactor or DC bus chokes of equivalent impedance.

B. Output Filtering: For separation between motor and VFD of greater than 100 feet, provide dV/dT filters.

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for the First Environment restricted level (Category C2).

2.05 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

C. Bypass Controller: Two-contactor-style full-voltage (across-the-line) type bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
   1. Bypass Contactor: Load-break, IEC-rated contactor.
   2. Output Isolating Contactor: Non-load-break, IEC-rated contactor.

3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

2.06 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFD suitable for variable-speed service to multiple motors. Overload protection shuts down VFD and motors served by it, and generates fault indications when overload protection activates.
   1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.

B. Damper control circuit with end-of-travel feedback capability.

C. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station or smoke-control fan controller, this password-protected input:
   1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
   2. VFDs Without a Bypass System: Forces VFD to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
      a. Final speed setting to be determined during commissioning, testing, and balancing of the ventilation system.
   3. VFDs With a Bypass System: Forces VFD to transfer to bypass mode and operate motor at full speed.
   4. Causes display of override mode on the VFD display.
   5. Reset VFD to normal operation on removal of override signal automatically.

D. Communication Port: RJ-45 port.

2.07 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Mechanical Rooms and Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: Type 12:
   3. Outdoor Locations: Type 4X.
   4. Wash-Down Areas: Type 4X, stainless steel.
   5. Other Wet or Damp Indoor Locations: Type 4.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.08 ACCESSORIES

A. Phase-Failure: Solid-state sensing circuit with isolated output contacts for hard-wired connections.

B. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

C. Programming Tools: To support the drive’s life cycle from startup and monitoring, to backup, and performance tuning.

2.09 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to manufacturers’ standard procedures and in accordance with ISO 9001, latest revision.
   1. Test each VFD while connected to a full motor load that is comparable to that for which the VFD is rated, at rated drive amperes at 105 degrees Fahrenheit in a temperature chamber.
   2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Test and inspection reports shall be available upon request.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks.

B. Roof-Mounting Controllers: Install VFD on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

E. Controllers shall be located so that door can be fully opened without interference.

3.03 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 23 05 53 “Identification for HVAC Piping and Equipment."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.

6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFDs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.05 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

3.06 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Final Acceptance.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges.

E. Set field-adjustable pressure switches.

F. All field adjustments shall be recorded and kept in cabinet with drawings.

3.07 STORAGE AND PROTECTION

A. Replace VFDs whose interiors have been exposed to water or other liquids prior to Final Acceptance.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Identification for raceway and metal-clad cable.
   2. Identification for conductors and communication and control cable.
   3. Underground-line warning tape.
   4. Warning labels and signs.
   5. Instruction signs.
   6. Equipment identification labels.
   7. Miscellaneous identification products.
   8. Labeling for Fault Current Levels.

1.02 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.03 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

1.04 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.01 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.02 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

2.03 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line.

2.04 WARNING LABELS AND SIGNS

A. Comply with NFPA 70, 70E and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
1. Custom warning labels indicating the available Fault Current level shall meet NFPA 70E and applicable OSHA requirements.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.05 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.06 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

B. Nameplate material colors shall be:
1. Normal Power Color: Black-White-Black.
2. Standby Power Color: Orange-White-Orange (or other distinguishing color besides black or red)
3. Emergency Power Color: Red-White-Red.

2.07 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
1. Minimum Width: 3/16 inch.

2. Tensile Strength: 50 lb, minimum.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.
5. Interior Ferrous Metal:
   a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
      1) Primer: Interior ferrous-metal primer.
      2) Finish Coats: Interior semigloss acrylic enamel.
6. Interior Zinc-Coated Metal (except Raceways):
   a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
      1) Primer: Interior zinc-coated metal primer.
      2) Finish Coats: Interior semigloss acrylic enamel.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws; if the screw sharp end is protected, otherwise rivets shall be used.

PART 3 EXECUTION

3.01 APPLICATION

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange self-adhesive vinyl label.

B. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
1. General 120/208V Equipment including optional standby and legally required standby: Black label with white text.
2. General 277/480V Equipment including optional standby and legally required standby: Orange label with black text.
3. Telecom/Data and Security Systems: Blue label with white text.
4. BAS Controls: Yellow label with black text.
5. Fire Alarm: Red label with black text

C. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

E. Cable Labels: Each branch circuit and each feeder shall be tagged in each panelboard gutter and in all pull or junction boxes, wire trough, etc. Tags in panelboard gutters shall indicate circuit. Tags in junction boxes and pull boxes shall indicate the circuit or feeder numbers and its point of origin. Tags for branch circuits shall be printed cloth or vinyl plastic with self-stick pressure adhesive.

F. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

J. Instruction Signs:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   2. Equipment to Be Labeled (All may not apply to this project):
      a. Panelboards, electrical cabinets, and enclosures.
      b. Access doors and panels for concealed electrical items.
      c. Electrical switchgear and switchboards.
      d. Transformers.
      e. Emergency system boxes and enclosures.
      f. Disconnect switches.
      g. Enclosed circuit breakers.
      h. Motor starters.
      i. Push-button stations.
      j. Power transfer equipment.
      k. Contractors.
      l. Remote-controlled switches, dimmer modules, and control devices.
      m. Battery inverter units.
      n. Battery racks.
      o. Power-generating units.
      p. Voice and data cable terminal equipment.
      q. Television/audio components, racks, and controls.
      r. Fire-alarm control panel and annunciators.
      s. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
      t. Monitoring and control equipment.
      u. Uninterruptible power supply equipment.
      v. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

w. Dimmers.
x. Transformers.

3. Information as specified below shall be provided for the equipment in addition to any marking requirements for Identification, Warnings, Operation, etc.
   a. Switchgear, switchboards, transfer switches and similar pieces of equipment shall have major equipment identification plate and feeder identification plates with information as specified herein.
   b. Panelboards: Panelboards and similar pieces of equipment shall have major equipment identification plate with information as specified herein
      1) Panelboard schedules shall be typed to indicate type of load served and its location.
   c. Safety switches, service entrance switches, motor starters or similar pieces of equipment shall have equipment identification plate with information as specified herein.
   d. Transformers: Each transformer shall have engraved nameplate showing its primary and secondary voltage and KVA.
   e. Fused Equipment
      1) Fused equipment shall have preprinted manufacturer's label or approved substitute placed inside or next to fuses for devices using fuses.
      2) This applies to both power and control fuses.
      3) Label shall clearly show type and rating of fuses used.
   f. Self-contained push-buttons, selector switches and control toggle switches may be identified by factory-engraved device plates, however, if not available, provide plates to identify what device controls.
   g. Junction Boxes
      1) Provide nameplate on junction box for appliances and motor that do not have local disconnect.
      2) Nameplate shall indicate panel, circuit and location of panel. Lettering shall be 1/4" high.
   h. Owner Furnished Equipment
      1) Provide nameplates for equipment furnished by Owner.
   i. Lettering shall be 1/4" high.
   j. Systems Control Panels
      1) Schedules shall be typed to indicate device controlled and its location.
      2) All terminals in systems control panels shall be labeled (numbered or otherwise identified) so as to correspond with schedule.
      3) Systems control cabinets shall have major identification plate similar to that of panelboard/branch circuit numbering and identification system.

3.02 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Fasteners for Nameplates and Signs: Two-part epoxy, machine, stainless-steel screws with nuts; screw sharp end protected.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
2. Colors for 208/120-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral: White
   e. Ground: Green
3. Colors for 480/277-V Circuits:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: Neutral Gray
   e. Ground: Green
4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

J. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

K. Raceway Boxes: All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with colors to match the surface color scheme outlined in Equipment Identification labels. This includes covers on boxes above lift-out and other type accessible ceilings. For emergency circuits, paint one half of box green and other half blue or black depending on voltage.
   1. Blank-off the center portion of the cover plate with 2” wide tape prior to painting. After painting with the tape removed, the circuit labeling shall be indicated on the non-painted surface of the cover plate using permanent black marker.

L. Empty Conduit: All empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate. Identification shall be by tags with string or wire attached to conduit or outlet.

M. Arc Flash Labeling: The Engineer will provide arc flash labels for all panels. The contractor shall be responsible for installing the labels on the associated panels.

END OF SECTION

SECTION 26 05 73.16 - COORDINATION STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
   1. Study results shall be used to determine coordination of series-rated devices.

1.02 DEFINITIONS

A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

D. Power System Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

F. SCCR: Short-circuit current rating.

G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

H. Single-Line Diagram: See "One-Line Diagram."

1.03 ACTION SUBMITTALS

A. Product Data:
   1. For computer software program to be used for studies.
   2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
      a. Coordination-study input data, including completed computer program input data sheets.
      b. Study and equipment evaluation reports.
   3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Engineer for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. For Power System Analysis Software Developer.
   2. For Power Systems Analysis Specialist.
   3. For Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
   1. The following are from the Coordination Study Report:
      a. Final one-line diagram.
      b. Final protective device coordination study.
      c. Coordination study data files.
      d. List of all protective device settings.
      e. Time-current coordination curves.
      f. Power system data.

1.06 QUALITY ASSURANCE

A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications:
   1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
   2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

F. Field Adjusting Agency Qualifications:
   1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
   2. A member company of NETA.
   3. Acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Software: SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
   1. Optional Features:
      a. Arcing faults.
      b. Simultaneous faults.
      c. Explicit negative sequence.
      d. Mutual coupling in zero sequence.

2.02 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:
   1. Protective device designations and ampere ratings.
   2. Conductor types, sizes, and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.
   6. Any revisions to electrical equipment required by the study.

D. Protective Device Coordination Study:
   1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
      a. Phase and Ground Relays:
         1) Device tag.
         2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
         3) Recommendations on improved relaying systems, if applicable.
      b. Circuit Breakers:
         1) Adjustable pickups and time delays (long time, short time, and ground).
         2) Adjustable time-current characteristic.
         3) Adjustable instantaneous pickup.
         4) Recommendations on improved trip systems, if applicable.
      c. Fuses: Show current rating, voltage, and class.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
   2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
   3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
   4. Plot the following listed characteristic curves, as applicable:
      a. Power utility's overcurrent protective device.
      b. Medium-voltage equipment overcurrent relays.
      c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
      d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
      e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
      f. Cables and conductors damage curves.
      g. Ground-fault protective devices.
      h. Motor-starting characteristics and motor damage points.
      i. Generator short-circuit decrement curve and generator damage point.
      j. The largest feeder circuit breaker in each motor-control center and panelboard.
   5. Maintain selectivity for tripping currents caused by overloads.
   6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
   7. Provide adequate time margins between device characteristics such that selective operation is achieved.

8. Comments and recommendations for system improvements.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
   1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.02 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the overcurrent protective device study.
   1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Engineer's attention.
   2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
   1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Electrical power utility impedance at the service.
   3. Power sources and ties.
   4. Short-circuit current at each system bus (three phase and line to ground).
   5. Full-load current of all loads.
   6. Voltage level at each bus.
   7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
   8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
   9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
   10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
   11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
   12. Maximum demands from service meters.
   13. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
   14. Motor horsepower and NEMA MG 1 code letter designation.
   15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
   16. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
   17. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
      a. Special load considerations, including starting inrush currents and frequent starting and stopping.

b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.03 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Retain first subparagraph below when authorities having jurisdiction do not require
3. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:
1. Device shall not operate in response to the following:
a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:
1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures

that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.

K. Include the arc fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

M. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
   3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.
   4. Include in the report identification of any protective device applied outside its capacity.

3.04 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
   1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
   2. Determine load flow and voltage drop based on 80 percent of the design capacity of load buses.
   3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.05 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect operation of other utilization equipment on system supplying the motor.

3.06 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.07 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

3.08 ARC FLASH ANALYSIS

A. The Engineer of Record will perform an Arc Flash Analysis of the installed system after the completion of the coordination study. The Arc Flash Labels for each panel will be provided by the Engineer and will be installed on the panels by the contractor.

END OF SECTION

SECTION 26 08 13 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The purpose of this section is to specify Division 26 contractor responsibilities in the commissioning (Cx) process.

B. Commissioning requires the participation of the Division 26 contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019113, General Commissioning Requirements. The Division 26 contractor shall be familiar with all parts of Section 019113 and the Cx Plan issued by the Commissioning Authority (CxA) and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

C. Section includes Cx process requirements for the following electrical systems, assemblies, and equipment:

1. Electrical systems including all renewable electrical generation (1.5.1A.1F)
    a. Metering and submetering
    b. Emergency power and automatic transfer equipment
    c. Electrical Power Distribution Systems (including panel and switchboard arc-testing and lightning protection impedance testing by others – 25% sample)
    d. Lighting Controls (Occupancy and daylighting – 25% sample)
    e. Fire alarm systems
        1) Interface with HVAC systems
        2) Elevator recall and shutdown
        3) Fire suppression/protection systems (limited to fire pump testing by others)
        4) Smoke Pressurization fans, interface with other life safety systems including fire alarm, security systems and building pressurization interface.
    f. Fire and smoke dampers installation and operation (25% sample)
    g. Security system

1.3 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process, as specifically related to the electrical systems, are provided in this section.

B. Refer to Section 019113 and the Cx Plan for all typical commissioning process requirements for each team member.

C. Each Contractor and subcontractor shall review this Section and shall include in their bids cost for carrying out the work described, as it applies to each Division and Section of these specifications, individually and collectively.

D. The commissioning responsibilities applicable to the contractors of Division 26 are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

1. Include the cost of commissioning work in the contract price
2. Attend a commissioning kick-off meeting and other meetings scheduled by the CxA as necessary to facilitate the Cx process, as indicated in specification section 019113.
3. Contractors shall provide the CxA with cut sheets and shop drawing submittals of commissioned equipment.
4. Provide additional requested documentation, prior to O&M manual submittals, to the CxA for development of Pre-Functional (PFC) and Functional Performance Testing (FPT) procedures.
    a. This will include detailed manufacturer installation and startup, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the CxA.
    b. The CxA may request further documentation necessary for the commissioning process.
    c. This data request may be made prior to normal submittals.
5. Provide a copy of the equipment submittals of commissioned equipment, through normal channels, to the CxA for review and comment.
6. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
7. Provide assistance to the CxA in preparing the specific FPT procedures specified in theCx Plan (prepared by the CxA), Section 019113 and this section. Contractor shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
8. Develop a full startup and initial checkout plan using manufacturer's startup procedures and PFCs from the CxA. Submit manufacturer's detailed startup procedures and the full startup plan and procedures and other requested equipment documentation to CxA for review and comment prior to startup. Refer to Section 019113 for further details on startup plan preparation.
9. During the startup and initial checkout process, execute and document the electrical-related portions of the PFCs provided by the CxA for all commissioned equipment.
10. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
11. Address current A/E punch list items before functional performance testing.
12. Provide skilled technicians to execute starting of equipment and to execute the FPTs. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
13. Perform FPT under the direction of the CxA for specified equipment in the Cx Plan, Section 019113 and this Section. Assist the CxA in interpreting the monitoring data, as necessary.
14. Correct deficiencies as indicated by the CxA and directed by the OPM and/or A/E and retest the equipment.
15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
16. During construction, maintain as-built/record red-line drawings and CAD drawings and provide final record drawings for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).

17. Provide training of the Owner's operating personnel using expert qualified personnel, as specified.
18. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.
2. Correct deficiencies and make necessary adjustments to O&M manuals and record drawings for applicable issues identified in any seasonal testing.
3. Participate in the near-warranty end (ten month) post occupancy visit.

1.4 RELATED WORK

A. Refer to Section 019113 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 019113 for systems to be commissioned.

1.5 SUBMITTALS

A. Division 26 shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 019113 for additional Division 26 requirements.

1.6 WEB-BASED COMMISSIONING PORTAL

A. All general and major contractors participating in the Cx process shall use the web-based Cx Portal, CxAlloy ("Portal" or "CxAlloy") to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Startup Documentation, PFCs, FPTs and results, Issues Log tracking, project documents and deliverables. It also serves as a collaborative e-mail hub to facilitate, automate, and track communications between Parties relating to the Cx process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Division 26 contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division 26 systems and equipment.

B. Refer to Section 019113 for additional Division 26 requirements.

C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the contractor. The manufacturer shall provide the test equipment, demonstrate its use and assist the CxA in the Cx process.

2.2 INCIDENTAL EQUIPMENT

A. The Division 26 contractor shall provide all scaffolds, staging, ladders and accessories required to allow testing agencies, consultants and Owner's staff safe access to equipment, electrical boxes and other devices located above floor level.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Section 019113 for additional meeting requirements.

B. Participation at various commissioning meetings shall depend on the purpose of the meeting and may consist of, but not be limited to, the following members of the project commissioning team: the Owner's representative (i.e. project manager and/or facility staff), the CxA, the CM/GC, subcontractors and/or manufacturer's technical representative as required, the architect/engineer (A/E), and any specialists deemed appropriate by the Cx team.

C. All the listed Cx team members shall participate in the Cx kick-off meeting.

D. Participate, as applicable, in Cx coordination meetings in accordance with related Section 019113.

E. Participate, as needed, in deficiency resolution meetings.

3.2 STARTUP

A. The electrical contractor shall follow the startup and initial checkout procedures and PFCs listed in the Responsibilities list in this section and Section 019113. The Division 26 contractor has startup responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the CxA or Owner.

B. FPT is intended to begin upon completion of a system. FPT will not proceed prior to the completion of systems, or sub-systems, which includes completion of PFCs and approval of any necessary testing requirements.

3.3 PRE-FUNCTIONAL CHECKLISTS

A. Sampling Strategy: 100% of systems and equipment shall have PFCs completed and submitted for review and approval prior to functional performance testing. The CxA may observe the Contractor's completion of the PFCs.

B. Typical aspects of electrical PFCs verify that the equipment matches the approved submittal, is installed properly, is started-up (and startup is documented) and integrated disciplines (i.e. electrical, equipment vendors, controls) have completed their work required for the equipment and system to function in its entirety. Examples would include spot checking of wiring/termination point-to-points and verification of alarm point parameters and messages.

3.4 TESTING PREPARATION

A. Inspect and verify the position of each device and interlock identified on checklists.

B. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, started, quality control tested, and code tested (as applicable) and are operating according to the Contract Documents.

C. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest setpoints have been recorded.

3.5 FUNCTIONAL PERFORMANCE TESTS

A. FPT is intended to begin upon completion and startup of a system and completion of PFCs. Functional testing may proceed prior to the completion of systems or sub-systems at the

discretion of the CxA and Owner. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including PFCs as soon as possible.

B. Refer to Section 019113 for a description of the process.

C. Sampling Strategy:

1. Electrical systems including all renewable electrical generation (1.5.1A.1F)
    a. Metering and submetering
    b. Emergency power and automatic transfer equipment
    c. Electrical Power Distribution Systems (including panel and switchboard arc-testing and lightning protection impedance testing by others – 25% sample)
    d. Lighting Controls (Occupancy and daylighting – 25% sample)
    e. Fire alarm systems
        1) Interface with HVAC systems
        2) Elevator recall and shutdown
        3) Fire suppression/protection systems (limited to fire pump testing by others)
        4) Smoke Pressurization fans, interface with other life safety systems including fire alarm, security systems and building pressurization interface.
    f. Fire and smoke dampers installation and operation (25% sample)
    g. Security system

D. Refer to Section 011913, Sampling for the Sampling/Failure Rate.

E. Typical aspects of electrical FPTs verify that systems, subsystems and equipment function interactively and throughout the full range of operating conditions (e.g. low load, design load, component failures, alarm conditions, safety interlocks including with life safety systems, etc.) and modes (e.g. normal shutdown, normal auto position, normal manual position, power failure including control power, emergency power, unoccupied, fire alarm, etc.). The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Positive confirmation of state/status shall be shown both locally and via the BAS, as specified in the Contract Documents.

F. Development of Test Procedures: Before test procedures are written, the CxA shall obtain project contract documentation and a current list of change orders and RFI's affecting equipment or systems, including an updated points list, program code, control sequences and parameters and electrical coordination study. The CxA shall develop specific test procedures and forms for evaluating performance of all integral components and their functioning as a complete unit within design requirements and manufacturer's published data. Prior to execution, the CxA shall provide a copy of the test procedures to the Contractors who shall review the tests for feasibility, safety, equipment and warranty protection.

3.6 TESTING DOCUMENTATION, NON-CONFORMANCE AND ACCEPTANCE

A. Refer to Section 019113 for specific details on non-conformance issues relating to PFCs and tests.

B. Refer to Section 019113 for issues relating to functional performance tests.

3.7 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in the Contract Documents.

B. The Division 26 shall compile and prepare documentation for all equipment and systems covered in Division 26 and deliver this documentation to the CM/GC for inclusion in the O&M manuals.

C. The CxA shall receive a copy of the O&M manuals for concurrent review and comment with the A/E.

3.8 TRAINING OF OWNER PERSONNEL

A. The CM/GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed in accordance with Division 1 requirements. Refer to Section 019113 for additional details.

B. The CxA shall be responsible for reviewing and providing comments for the adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 019113 for additional details.

C. Electrical Contractor: The electrical contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan eight (8) weeks before the planned training according to the outline described in Section 019113.
2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
3. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual, the system will be repaired or adjusted as necessary and the demonstration repeated.
4. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the startup technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
5. The training sessions shall follow the outline in the Table of Contents of the O&M manual and illustrate whenever possible the use of the O&M manuals for reference.
6. Training shall include:
    a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventive maintenance, special tools needed and spare parts inventory suggestions. The training shall include startup, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
    c. Discussion relevant health and safety issues and concerns.
    d. Discussion warranties and guarantees.
    e. Common troubleshooting problems and solutions.
    f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
    g. Discussion of any peculiarities of equipment installation or operation.

D. Hands-on training shall include startup, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance of all pieces of equipment.

E. The electrical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

F. Training shall occur after functional testing is complete, unless approved otherwise by the Owners.

3.9 DEFERRED TESTING

A. Refer to Section 019113 for requirements of deferred testing.

3.10 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the startup and initial checkout plan and PFCs described in Section 019113.

END OF SECTION 260813

SECTION 26 09 23 - LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following lighting control devices:
   1. Time switches.
   2. Outdoor photoelectric switches.
   3. Indoor occupancy and vacancy sensors.
   4. Lighting contactors.
   5. Emergency shunt relays.
   6. UL 924 Emergency Lighting Relay Control Device

1.02 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show installation details for occupancy, vacancy, and light-level sensors.
   1. Provide scaled plan layouts of all occupancy and vacancy sensor locations based upon the manufacturer's suggested layout for their equipment in full compliance with these specifications.
      a. Show sensor type being supplied for each sensor location and the area of coverage for each sensor.
   2. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals per 2018 North Carolina Energy Conservation Code Section C408.3.2 Lighting System Operation Manual Prescriptive Criterion. Include the following:
   1. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.
   2. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended re-lamping shall be clearly identified.
   3. A schedule for inspecting and recalibrating all lighting controls.
   4. A narrative of how each system is intended to operate, including recommended set points.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 PRODUCTS

2.01 TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Lithonia Lighting; Acuity Lighting Group, Inc.

2. Square D; Schneider Electric.
3. TORK.
4. Watt Stopper (The).

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
1. Contact Configuration: SPST.
2. Contact Rating: 20-A inductive or resistive, 277-V ac.
3. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
5. Astronomic Time: All channels.
6. Battery Backup: For schedules and time clock.
7. Lighting Delay Switch with OFF blink warning to operate a mechanically held contactor (with coil clearing contacts), of maximum size. Control shall include four terminals for input power (120/(208-240)/277VAC), two for remote Time-of-Day control via any maintained contact time switches, three for load output wiring, and three input terminals that will accept a momentary contact closure for remote override. Control shall function to turn on and off Load output lighting per Time-of-Day schedules, or via remote override input for a user preset time period of 1/2, 1, 1-1/2, 2, 6, 9, or 12 hours. Control shall blink the lights when an off command is received, which shall warn the user to activate an extension of time via its remote override input. If extension of time is not activated the lights will turn off in the user preset time delay or 1 to 5 minutes.

2.02 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Lithonia Lighting; Acuity Lighting Group, Inc.
2. Square D; Schneider Electric.
3. TORK.
4. Watt Stopper (The).
5. Fifth Light (Cooper)

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 2 minute minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
5. Contact voltage rating: Suitable for the circuit being controlled.

C. Control of site lighting fixtures shall be by means of a common building mounted photocell and/or contactor.

2.03 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Lithonia Lighting; Acuity Lighting Group, Inc.
2. Watt Stopper (The).
3. Fifth Light (Cooper)
4. SensorWorx (BLP Technologies)

B. General Requirements for Sensors:
   1. Wall- or ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
   2. Dual technology.
   3. Separate power pack.
   4. Hardwired connection to switch/lighting load; and BAS and lighting control system.
   5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   6. Operation:
      a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
      b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the power pack.
      a. Provide auxiliary isolated output relay contacts to interface with BAS for standby control of the terminal units associated with the lighting zone. Operation of relay shall be configurable. BAS connection to relay shall be by Division 23.
   8. Power Pack: Dry contacts rated for 20 A ballast load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
   9. Mounting:
      a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
      b. Relay: Externally mounted through a 1/2 inch knockout in a standard electrical enclosure.
      c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   10. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
   11. Bypass Switch: Override the "on" function in case of sensor failure.
   12. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
   1. Sensitivity Adjustment: Separate for each sensing technology.
   2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
   3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.04 WALL OCCUPANCY SENSORS

A. Wall-Switch Sensors:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Fifth Light (Cooper).
      b. Watt Stopper (The); WS-200.
      c. Acuity
   2. Description: Dual Technology type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

B. Wall-Switch Sensors:
   1. Products: Subject to compliance with requirements, provide one of the following:

a. Fifth Light (Cooper)
b. Wattstopper
c. Acuity.

2. Description: Dual Technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

C. Long-Range Wall-Switch Sensors (Dual Technology Type):
1. Products: Subject to compliance with requirements, provide one of the following:
a. Fifth Light (Cooper)
b. Watt Stopper (The); DT-200.
c. Acuity
2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft.

2.05 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Fifth Light (Cooper)
2. Lithonia Lighting; Acuity Lighting Group, Inc.
3. Wattstopper

B. Description: Electrically operated and mechanically held, combination type with non-fused disconnect, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.06 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Wattstopper
2. Fifth Light
3. Acuity
4. The Bodine Company Inc.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
1. Coil Rating: 277 V.

2.07 UL 924 EMERGENCY LIGHTING RELAY CONTROL DEVICE

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. The Bodine Company Inc.
2. Fifth Light
3. Wattstopper
4. Acuity

B. Description: UL 924 listed transfer relay switching system with integral test switch, normal and emergency power indication lights.
1. Emergency egress lighting circuits as shown on the drawings shall be provided with an automatic Emergency Lighting Relay Control system.
2. The device shall be capable of bypassing the local switching means when normal utility power has been lost.

3. The device shall consist of relay switching circuitry, a test switch, a normal power indicator light and an alternate power indicator light.
4. All components shall be installed from the manufacturer in a single enclosure not to exceed 9” H x 6” W x 3.5” deep.
5. The system shall be rated and shall sense normal power at 120-volts through 277-volts AC 50/60 Hz at 20 amperes of maximum lighting load.
6. The device shall draw 4.5 mA and 4.0 watts during normal sensing operation.
7. The device shall comply with the requirements of the latest edition of the NEC.
8. The device shall be UL 924 tested and listed for field installation in indoor or damp locations.
9. The device shall be warranted for a full five years from date of purchase.
10. For dimming fixtures, UL 924 device shall be capable of returning the light level to full brightness in an event of a loss of power.

2.08 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

3.03 INSTALLATION OF CONTACTORS

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.04 INSTALLATION OF WIRING

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

F. Complete wiring systems shall be color coded according to the manufacturer's recommendations and conductors must be tagged or identified at terminals.

3.05 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.06 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Architect.

B. Tests and Inspections:
   1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Nonconforming Work:
   1. Lighting control devices will be considered defective if they do not pass tests and inspections.
   2. Remove and replace defective units and retest.
   3. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements

D. Prepare test and inspection reports.

E. Manufacturer Services:
   1. Engage factory-authorized service representative to support and supervise field tests and inspections.

3.07 ADJUSTING

A. Occupancy Adjustments: When requested within 90 days from date of Final Acceptance, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
   1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
   2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
   3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

3.09 SERVICE MAINTENANCE AGREEMENT

A. Technical Support and Upgrade Service included for 3 years. Notify college 45 days prior to any software update. Include EasyVista CMMS.

END OF SECTION

SECTION 26 09 33 - CENTRAL DIMMING CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes a networked lighting control system comprised of the following components:
   1. System Software Interfaces
      a. Management Interface
      b. Historical Database and Analytics Interface
      c. Visualization Interface
   2. System Backbone and Integration Equipment
      a. System Controller
   3. Wired Networked Devices
      a. Wall Stations
      b. Digital Key Switches
      c. Auxiliary Input/Output Devices
      d. Occupancy and Photocell Sensors
      e. Wall Switch Sensors
      f. Power Packs and Secondary Packs
      g. Relay and Dimming Panel
      h. Bluetooth® Low Energy Programming Device
      i. Communication Bridge

B. The networked lighting control system shall meet all of the characteristics and performance requirements specified herein.

C. The contractor shall provide, install and verify proper operation of all equipment necessary for proper operation of the system as specified herein and as shown on applicable drawings.

1.02 DEFINITIONS

A. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.

B. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

C. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.

D. Low Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.

E. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

F. SCR: Silicon-controlled rectifier.

G. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Bill of Materials necessary to install the networked lighting control system.
   2. Product Specification Sheets indicating general device descriptions, dimensions, electrical specifications, wiring details, and nomenclature.
   3. Riser Diagrams showing device wiring connections of system backbone and also typical per room/area type.
   4. Information Technology (IT) connection information pertaining to interconnection with facility IT networking equipment and third-party systems.
   5. Other Diagrams and Operational Descriptions – as needed to indicate system operation or interaction with other system(s).

6. Contractor Startup/Commissioning Worksheet (must be completed prior to factory start-up).
7. Service Specification Sheets indicating general service descriptions, including startup, training, post-startup support, and service contract terms.
8. Hardware and Software Operation Manuals.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
1. Include elevation views of front panels of control and indicating devices and control stations.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals per 2018 North Carolina Energy Conservation Code Section C408.3.2 Lighting System Operation Manual Prescriptive Criterion. Include the following:
1. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.
2. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended re-lamping shall be clearly identified.
3. A schedule for inspecting and recalibrating all lighting controls.
4. A narrative of how each system is intended to operate, including recommended set points.
5. In addition to the requirements above provide the following for central dimming controls with remote-mounting dimmers:
a. Software manuals.
b. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
c. Operation of adjustable zone controls.
d. Testing and adjusting of panic and emergency power features.

D. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain controls from a single source with total responsibility for compatibility of lighting control system components specified in this Section, and in Division 26 Section "Lighting Control Devices."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

E. System electrical components shall be listed or recognized by a nationally recognized testing laboratory (e.g., UL, ETL, or CSA) and shall be labeled with required markings as applicable.

F. System shall be listed as qualified under DesignLights Consortium Networked Lighting Control System Specification V2.0.

G. System luminaires and controls are certified by manufacturer to have been designed, manufactured and tested for interoperability.

H. All components shall be subjected to 100% end of line testing prior to shipment to the project site to ensure proper device operation.

I. All components and the manufacturing facility where product was manufactured must be RoHS compliant.

J. Installation and Startup Qualifications
1. System startup shall be performed by qualified personnel approved or certified by the manufacturer.

1.05 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:
   1. Division 26 Section "Lighting Control Devices."

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Damage from transient voltage surges.
   2. Warranty Period: Cost to repair or replace any parts for five years from date of Final Acceptance.
   3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

1.07 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Final Acceptance, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Acceptance. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design Manufacturer: Wattstopper.
   1. Basis of Design System: Wattstopper LMCP Series

B. Or approved equal manufacturer meeting the design intent shown on the drawings and details in the specifications by one of the following:
   1. Acuity
   2. Fifth Light (Cooper)

2.02 GENERAL SYSTEM REQUIREMENTS

A. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.

B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.
   1. Alternative Line-Voltage Surge Suppression: Comply with requirements in Division 26 Section "Surge Protective Devices for Low-Voltage Electrical Power Circuits".

C. Dimmers and Dimmer Modules: Comply with UL 508.
   1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
   2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

2.03 SYSTEM DESCRIPTION

A. System Architecture

1. System shall have an architecture that is based upon three main concepts: (1) networkable intelligent lighting control devices, (2) standalone lighting control zones using distributed intelligence, (3) system backbone for remote, time based and global operation between control zones.
2. Intelligent lighting control devices shall have individually addressable network communication capability and consist of one or more basic lighting control components: occupancy sensor, photocell sensor, relay, dimming output, contact closure input, analog 0-10V input, and manual wall station capable of indicating switching, dimming, and/or scene control. Combining one or more of these components into a single device enclosure shall be permissible so as to minimize overall device count of system.
3. System must be capable of interfacing directly with luminaires and control components such that either low voltage network cabling or wireless RF communication is used to interconnect luminaires and control components such as sensors, switches and system backbone (see Control Zone Characteristics sections for each type of network connection, wired or wireless).
4. Lighting control zones consisting of one or more luminaires and intelligent lighting control devices and shall be capable of providing automatic control from sensors (occupancy and/or photocell) and manual control from local wall stations without requiring connection to a higher-level system backbone; this capability is referred to as “distributed intelligence.”
    a. Lighting control zones (wired and wireless) of at least 128 devices per zone shall be supported.
5. Intelligent lighting control devices shall support individual (unique) configuration of device settings and properties, with such configuration residing within the intelligent control devices.
6. Intelligent lighting control devices shall have distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones shall operate according to their defined default settings and sequence of operations.
7. Lighting control zones shall be capable of being networked with a higher-level system backbone to provide time based control, remote control from inputs and/or systems external to the control zone, and remote configuration and monitoring through a software interface.
8. The system may include one or more system controllers that provide time-based control and global system control across multiple control zones and backbone network segments. The system controller also provides a means of connecting the lighting control system to a system software interface and building management systems via BACnet/IP protocol.
9. The system may include “communication bridge” devices that route communication from lighting control zones (wired or wireless) to and from the system controller, for purposes of decreasing system wiring requirements.
10. All system devices shall support remote firmware update, such that physical access to each device is not necessary, for purposes of upgrading functionality at a later date.

B. Wired Networked Control Zone Characteristics
1. Connections to devices within a wired networked lighting control zone and to backbone components shall be with a single type of low voltage network cable, which shall be compliant with CAT5e specifications or higher. To prevent wiring errors and provide cost savings, the use of mixed types of low voltage network cables shall not be permitted.
2. Devices in an area shall be connected via a “daisy-chain” topology; requiring all individual networked devices to be connected back to a central component in a “hub-and-spoke” topology shall not be permitted, so as to reduce the total amount of network cable required for each control zone.
3. System shall provide the option of having pre-terminated plenum rated low voltage network cabling supplied with hardware so as to reduce the opportunity for improper wiring and communication errors during system installation.
4. Following proper installation and provision of power, all networked devices connected together with low voltage network cable shall automatically form a functional lighting

control zone without requiring any type of programming, regardless of the programming mechanism (e.g., software application, handheld remote, pushbutton). The “out of box” default sequence of operation is intended to provide typical sequence of operation so as to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.

5. Once software is installed, system shall be able to automatically discover all connected devices without requiring any provisioning of system or zone addresses.
6. All networked devices shall have the ability to detect improper communication wiring and blink its’ LED in a specific cadence as to alert installation/startup personnel.
7. Networked control devices intended for control of egress and/or emergency light sources shall not require the use of additional, externally mounted UL924 shunting and/or 0-10V disconnect devices, so as to provide a compliant sequence of operation while reducing the overall installation and wiring costs of the system. The following types of wired networked control devices shall be provided for egress and/or emergency light fixtures:
   a. Low-Voltage power sensing: These devices shall automatically provide 100% light level upon detection of loss of power sensed via the low voltage network cable connection.
   b. UL924 Listed Line-Voltage power sensing: These devices shall be listed as emergency relays under the UL924 standard, and shall automatically close the load control relay and provide 100% light output upon detection of loss of power sensed via line voltage connection to normal power.

C. System Integration Capabilities
   1. The system shall interface with third party building management systems (BMS) to support two-way communication using the industry standard BACnet/IP or BACnet MS/TP protocols. The following system integration capabilities shall be available via BACnet/IP and BACnet MS/TP protocols:
      a. The system shall support control of individual devices, including, but not limited to, control of relay and dimming output.
      b. The system shall support reading of individual device status information. The available status will depend on the individual device type and capabilities, which may include but not be limited to, relay state, dimming output, power measurement, occupancy sensor status, and photocell sensor states or readings. All system devices shall be available for polling for devices status.
      c. The system shall support activation of pre-defined system Global Profiles (see Supported Sequence of Operations for further definition of Global Profile capabilities).
   2. The system shall support activation of Profiles (local or global) and Preset Scenes from third party systems by receiving dry contact closure output signals or digital commands via RS-232/RS-485. (See Supported Sequence of Operations for further definition of Profile and Scene Preset capabilities.)

D. Supported Sequence of Operations
   1. Characteristics and performance requirements herein shall be supported by the networked lighting control system.
   2. Control Zones
      a. Networked lighting control devices installed in an area (also referred to as a group of devices) shall be capable of transmitting and tracking occupancy sensor, photocell sensor, and manual switch information within at least 48 unique control zones to support different and reconfigurable sequences of operation within the area. These shall also be referred to as local control zones.
      b. Networked lighting control devices located in different areas shall be able to transmit and track information within at least 128 system-wide control zones to support required sequences of operation that may span across multiple areas. Occupancy and photocell commands shall be available across a single controller, and switch commands shall be available across single or multiple controllers. These shall also be referred to as global control zones.
   3. Wall station Capabilities

a. Wall stations shall be provided to support the following capabilities:
   1) On/Off of a local control zone and global control zone simultaneously, as required.
   2) Continuous dimming control of light level of a local control zone and global control zone simultaneously, as required.
   3) Preset Scenes that can activate a specific combination of light levels across multiple local and global channels, as required.
   4) Profile Scenes that can modify the sequence of operation for the devices in the area (group) in response to a button press. This capability is defined as supporting “Local Profiles” and is used to dynamically optimize the occupant experience and lighting energy usage. Wall stations shall be able to manually start and stop Local Profiles, or the local profile shall be capable of ending after a specific duration of time between 5 minutes and 12 hours. Parameters that shall be configurable and assigned to a Local Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.

b. 3-way / multi-way control: multiple wall stations shall be capable of controlling the same local and global control zones, so as to support “multi-way” switching, dimming, preset scene, and profile scene control.

4. Occupancy Sensing Capabilities
   a. Local and global control: Occupancy sensors shall be configurable to control a local and global zone simultaneously, as required.
      1) Provide auxiliary isolated output relay contacts to interface with BAS for standby control of the terminal units associated with the local zone. Operation of relay shall be configurable. BAS connection to relay shall be by Division 23.
   b. Multi-sensor control: multiple occupancy sensors shall be capable of controlling the same local and global control zones. This capability combines occupancy sensing coverage from multiple sensors without consuming multiple control zones.
   c. System shall support the following types of occupancy sensing sequence of operations:
      1) On/Off Occupancy Sensing
      2) Partial-On Occupancy Sensing
      3) Partial-Off Occupancy Sensing
      4) Vacancy Sensing (Manual-On / Automatic-Off)
   d. On/Off, Partial-On, and Partial-Off Occupancy Sensing modes shall function according to the following sequence of operation:
      1) Occupancy sensors shall automatically turn lights on to a designated level when occupancy is detected. To support fine tuning of Partial-On sequences the designated occupied light level shall support at least 100 dimming levels.
      2) Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. To support fine tuning of Partial-Off sequences the designated unoccupied dim level shall support at least 100 dimming levels. To provide additional energy savings and an enhanced occupant experience, the system shall also be capable of dimming the lights when vacant and then turning the lights off completely after an additional amount of time.
      3) Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage. Additional requirements and details for photocell sensing capabilities are indicated under Photocell Sensing Capabilities.
      4) At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this

manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

e. Vacancy Sensing mode (also referred to as Manual-On / Automatic-Off) shall function according to the following sequence of operation:
   1) The use of a wall station is required turn lights on. The system shall be capable of programming the zone to turn on to either to a designated light level or the previous user light level. Initially occupying the space without using a wall station shall not result in lights turning on.
   2) Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. To support fine tuning of Partial-Off sequences the designated unoccupied dim level shall support at least 100 dimming levels. To provide additional energy savings and an enhanced occupant experience, the system shall also be capable of dimming the lights when vacant and then turning the lights off completely after an additional amount of time.
   3) To minimize occupant impact in case the area or zone is still physically occupied following dimming or shutoff of the lights due to detection of vacancy, the system shall support an “automatic grace period” immediately following detection of vacancy, during which time any detected occupancy shall result in the lights reverting to the previous level. After the grace period has expired, the use of a wall station is required to turn lights on.
   4) Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage. Additional requirements and details for photocell sensing capabilities are indicated under Photocell Sensing Capabilities.
   5) At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

f. To accommodate different types of environments, occupancy time delays before dimming or shutting off lights shall be specifiable for control zones between 15 seconds to 2 hours.

5. Schedule and Global Profile Capabilities
   a. The system shall be capable of automatically modifying the sequence of operation for selected devices in response to any of the following: a time-of-day schedule, contact closure input state, manually triggered wall station input, RS-232/RS-485 command, and BACnet input command. This capability is defined as supporting “Global Profiles” and is used to dynamically optimize the occupant experience and lighting energy usage.
   b. Global profiles may be scheduled with the following capabilities:
      1) Global Profiles shall be stored within and executed from the system controller (via internal timeclock) such that a dedicated software host or server is not required to be online to support automatic scheduling and/or operation of Global Profiles.
      2) Global Profile time of day schedules shall be capable of being given the following recurrence settings: daily, specific days of week, every “n” number of days, weekly, monthly, and yearly. Lighting control profile schedules shall support definition of start date, end date, end after “n” recurrences, or never ending. Daylight savings time adjustments shall be capable of being performed automatically, if desired.
      3) Global Profile Holiday Schedules should follow recurrent settings for specific US holiday dates regardless if they always occur on a specific date or are determined by the day/week of the month.

4) Global Profiles shall be capable of being scheduled to run according to timed offsets relative to sunrise or sunset. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.
5) System shall support blink warning and timed extension capabilities. At the end of a scheduled period, the system shall be capable of providing a visible “blink warning” 5 minutes prior to the end of the schedule. Wall stations may be programmed to provide timed overrides that turn the lights on for an additional period of time. Timed override duration shall be programmable for each individual device, zone of devices, or customized group of devices, ranging from 5 minutes to 12 hours.
6) Software management interface shall be capable of displaying a graphic calendar view of profile schedules for each control zone.

c. System Global Profiles shall have the following additional capabilities:
1) Global Profiles shall be capable of being manually activated directly from the system controller, specially programmed input devices, scene capable wall stations, and the software management interface.
2) Global Profiles shall be selectable to apply to a single device, zone of devices, or customized group of devices.
3) Parameters that shall be configurable and assigned to a Global Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.

d. A backup of Local and Global Profiles shall be stored on the software’s host server such that the Profile backup can be applied to a replacement system controller or wall station.

2.04 SYSTEM SOFTWARE INTERFACES

A. Management Interface
1. System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.
2. Management interface must be compatible with industry-standard web browser clients, including, but not limited to, Microsoft Internet Explorer®, Apple Safari®, Google Chrome®, Mozilla Firefox®.
3. Management interface shall require all users to login with a User Name and Password, and shall support creation of at least 100 unique user accounts.
4. Management interface shall support at least three permission levels for users: read-only, read & change settings, and full administrative system access.
5. Management interface shall be capable of restricting access for user accounts to specific devices within the system.
6. All system devices shall be capable of being given user-defined names.
7. The following device identification information shall be displayed in the Management interface: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.
8. Management interface shall be able to read the live status of a networked luminaire or intelligent control device and shall be capable of displaying luminaire on/off status, dim level, power measurement, device temperature, PIR occupancy sensor status, microphonic occupancy sensor status, remaining occupancy time delay, photocell reading, and active Scenes or Profiles.
9. Management interface shall be able to read the current active settings of a networked luminaire or intelligent control device and shall be capable of displaying dimming trim levels, occupancy sensor and photocell enable/disable, occupancy sensor time delay and light level settings, occupancy sensor response (normal or vacancy), and photocell setpoints and transition time delays.

10. Management interface shall be able to change the current active settings and default settings for an individual networked luminaire or intelligent control device.
11. Management interface shall be capable of applying settings changes for a zone of devices or a group of selected devices using a single “save” action that does not require the user to save settings changes for each individual device.
12. A printable network inventory report shall be available via the management interface.
13. A printable report detailing all system profiles shall be available via the management interface.
14. All sensitive information stored by the software shall be encrypted.
15. All system software updates must be available for automatic download and installation via the internet.

B. Historical Database and Analytics Interface
1. System shall provide a historical database that stores device operational history and calculates energy usage for all networked luminaires and intelligent control devices.
2. System shall be capable of reporting lighting system events and performance data back to the historical database for display and analysis.
3. Historical database shall be capable of recording historical data for up to 20,000 networked devices for a period of at least 1 calendar year.
4. An “Energy Scorecard” shall be displayed that shows calculated energy savings in dollars, kWh, or CO2.
5. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc.).
6. Energy savings data shall be calculated for the system as a whole or for individual zones.
7. A time scaled graph showing all relay transitions shall be presented.
8. A time scaled graph showing a zones occupancy time delay shall be presented
9. A time scaled graph showing the total light level shall be presented.
10. User shall be able to customize the baseline run-time hours for a space.
11. User shall be able to customize up to four time-of-day billing rates and schedules.
12. Historical data shall be exportable from the Historical Database via a “CSV” type of file format.

C. Visualization and Programming Interfaces
1. System shall provide a web-based visualization interface that displays graphical floorplan.
2. Graphical floorplan shall offer the following types of system visualization:
    a. Full Device Option - A master graphic of the entire building, by floor, showing each control device installed in the project with zones outlined. This shall include, but not be limited to, the following:
        1) Controls embedded light fixtures
        2) Controls devices not embedded in light fixtures
        3) Occupancy Sensors
        4) Wall Switches and Dimmers
        5) Scene Controllers
        6) Networked Relays
        7) Bridges
        8) System Controllers
        9) Panels
        10) Zone outlines
    b. Zone Only Option - A master graphic of the entire building, by floor, showing only control zones outlined.
    c. Allow for pan and zoom commands so smaller areas can be displayed on a larger scale simply by panning and zooming each floor’s master graphic.
    d. A mouse click on any control device shall display the following information (as applicable):
        1) The device catalog number.
        2) The device name and custom label.
        3) Device diagnostic information.

4) Information about the device status or current configuration is available with an additional mouse click.

2.05 SYSTEM BACKBONE AND SYSTEM INTEGRATION EQUIPMENT

A. System Controller
1. Product Series: LMJA Network Controller
2. System Controller shall be multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.
3. System Controller shall have 32-bit microprocessor operating at a minimum of 1 GHz.
4. System Controller shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases.
5. System Controller shall perform the following functions:
   a. Time-based control of downstream wired and wireless network devices.
   b. Facilitation of global network switch communication between different system controllers.
   c. Linking into an Ethernet network.
   d. Integration with Building Management Systems (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.
   e. Connection to various software interfaces, including management interface, historical database and analytics interface, visualization interface, and personal control applications.
6. System Controller shall have an integral web server to support configuration, diagnostics and hosting of software interfaces.
7. Device shall have option for a graphical touch screen to support configuration and diagnostics.
8. Device shall have three RJ-45 networked lighting control ports for connection to any of the following:
   a. The graphical touch screen
   b. Wired communication bridges
   c. Direct connection to networked intelligent lighting control devices (up to 128 total devices per port)
9. Device shall be capable of communicating with wireless network bridges and software interfaces via LAN connection.
10. Device shall automatically detect all networked devices connected to it, including those connected to wired and wireless communication bridges.
11. Device shall have a standard and astronomical internal time clock.
12. Device shall have 2 switched RJ-45 10/100 BaseT Ethernet ports for local area network (LAN) connection.
    a. Ethernet connection shall support daisy chain wiring to other lighting control system LAN devices, such as other system controllers and wireless networked communication bridges.
    b. Ethernet connection shall support IPv4 and shall be capable of using a dedicated static or DHCP assigned IP address.
13. Device shall have 2 x USB 2.0 Expansion ports for 802.11 Wi-Fi Adapter enabling wireless connectivity including:
    a. Hot Spot
    b. Access Point
    c. Client
14. Each System Controller shall be capable of managing and operating at least 750 networked devices (wired or wireless).
    a. Multiple System Controllers may be networked together via LAN connection to scale the system up to 20,000 networked devices.
15. System Controller shall support BACnet/IP and BACnet MS/TP protocols to directly interface with BMS and HVAC equipment without the need for additional protocol translation gateways.

a. BACnet MS/TP shall support 9600 to 115200 baud rate.
b. System Controller shall be BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

16. System controller shall contain a “FIPS 140-2 Level 1 Inside” cryptographic module.
17. System controller shall be available within a NEMA 1 enclosure with Class 1 and Class 2 separation
    a. Enclosure shall support power input power of 120-277VAC, or optional 347VAC

2.06 WIRED NETWORK DEVICES

A. Wired Networked Digital Key Switches
1. Product Series: Wattstopper DLM Series
2. Devices shall recess into single-gang switch box and fit a standard GFI opening.
3. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
4. All switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
5. Devices shall have LED user feedback to provide indication of on/off status of the programmed lights or scene, as well as indication of device power.
6. Digital key switches shall support the following device options:
   a. Control Types Supported:
      1) On/Off
      2) On/Off/Dimming
      3) Preset Level Scene Type
      4) Reprogramming of other devices within daisy-chained zone so as to implement user selected lighting scene. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.
      5) Selecting a lighting profile to be run by the system’s upstream controller so as to implement a selected lighting profile across multiple zones. This shall support manual start/stop from the scene controller, or optionally programmed to automatically end after a user selectable duration between 5 minutes and 12 hours.
   b. Colors: Ivory, White, Light Almond, Stainless Steel

B. Wired Networked Auxiliary Input / Output (I/O) Devices
1. Product Series: LMIO
2. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.
3. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
4. Auxiliary Input/Output Devices shall be specified as an input or output device with the following options:
   a. Contact closure or Pull High input
      1) Input shall be programmable to support maintained or momentary inputs that can activate local or global scenes and profiles, activate lights at a preconfigured level, ramp light level up or down, or toggle lights on/off.
   b. 0-10V analog input
      1) Input shall be programmable to function as a daylight sensor.
   c. RS-232/RS-485 digital input
      1) Input supports activation of up to 4 local or global scenes and profiles, and on/off/dimming control of up to 16 local control zones.
   d. 0-10V dimming control output, capable of sinking up to 20mA of current
      1) Output shall be programmable to support all standard sequence of operations supported by system.
   e. Digital control output via EldoLED LEDcode communication

1) Output shall be programmable to support light intensity control, as well as optional correlated color temperature (CCT) control, of the connected luminaire.

C. Wired Networked Occupancy
1. Product Series: LMDC
2. Occupancy sensors shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
3. Sensors shall utilize dual technology, passive infrared (PIR) technology and microphonics, which detects occupant motion and sound, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic only or Microwave only based sensing technologies shall not be accepted.
4. All sensing technologies shall be acoustically passive, meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
5. System shall have ceiling, fixture, recessed & corner mounted sensors available, with multiple lens options available customized for specific applications.
6. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
7. All sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
8. Sensor programming parameter shall be available and configurable remotely from the software and locally via the device push-button.
9. Ceiling mount occupancy sensors shall be available with zero or one integrated dry contact switching relays, capable of switching 1 amp at 24 VAC/VDC (resistive only).
10. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.
11. Sensors shall have optional features for photosensor/daylight override, automatic dimming control, and low temperature/high humidity operation.
12. Photosensor shall provide for an on/off set-point, and a dead band to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
13. Photosensor and dimming sensor’s set-point and dead band shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.
14. Dead band setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
15. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The secondary daylight zone shall be capable of being controlled as an “offset” from the primary zone.
16. Provide auxiliary isolated output relay contacts to interface with BAS for standby control of the terminal units associated with the lighting zone. Operation of relay shall be configurable. BAS connection to relay shall be by Division 23.

D. Wired Networked Wall Switch Sensors
1. Product Series: LMDM
2. Devices shall recess into single-gang switch box and fit a standard GFI opening.
3. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.
4. All wall switch sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.
5. Devices with mechanical push-buttons shall provide tactile user feedback.
6. Wall switches sensors shall support the following device options:

a. User Input Control Types Supported: On/Off or On/Off/Dimming
b. Occupancy Sensing Technology: PIR only or Dual Tech acoustic
c. Daylight Sensing Option: Inhibit Photosensor
d. Colors: Ivory, White, Light Almond, Gray

E. Wired Networked Power Packs and Secondary Packs
1. Product Series: LMRC, BZ 150
2. Power Packs shall incorporate one optional Class 1 relay, optional 0-10 VDC dimming output, and contribute low voltage Class 2 power to the rest of the system.
3. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC) and carry a plenum rating.
4. Secondary Packs shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power.
5. Power Supplies shall provide system power only, but are not required to switch line voltage circuit.
6. Auxiliary Relay Packs shall switch low voltage circuits only, capable of switching 1 amp at 40 VAC/VDC (resistive only).
7. Communication shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors. Secondary packs shall receive low voltage power via standard low voltage network cable.
8. Power Pack programming parameters shall be available and configurable remotely from the software and locally via the device push-button.
9. Power Pack shall securely mount through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast/driver channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
10. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
11. Power/Secondary Packs shall be available with the following options:
    a. Power Pack capable of full 16-Amp switching of all normal power lighting load types, with optional 0-10V dimming output capable of up to 100mA of sink current.
    b. Secondary Pack with UL924 listing for switching of full 16-Amp Emergency Power circuits, with optional 0-10V dimming output capable of up to 100mA of sink current.
    c. Power and Secondary Packs capable of full 20-Amp switching of general purpose receptacle (plug-load) control.
    d. Secondary Pack capable of full 16-Amp switching of all normal power lighting load types.
    e. Secondary Pack capable of 5-Amps switching and dimming 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
    f. Secondary Pack capable of 5-Amps switching and dimming of 120/277 VAC magnetic low voltage transformers.
    g. Secondary Pack capable of 4-Amps switching and dimming of 120 VAC electronic low voltage transformers.
    h. Secondary Pack capable of louver/damper motor control for skylights.
    i. Secondary Pack capable of providing a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.
    j. Secondary Pack capable of switching 1 amp at 40 VAC/VDC (resistive only) with the intent to provide relay signal to auxiliary system (e.g. BMS).
    k. Power Supply capable of providing auxiliary bus power (no switched or dimmed load).

F. Wired Networked Relay and Dimming Panel
1. Product Series: LMCP Series

2. Relay and dimming panel shall be available with 4, 8, 12 or 16 individual relays per panel, with an equal number of individual 0-10V dimming outputs.
3. Optional Field Configurable Relays (FCR) used shall have the following required properties:
    a. Configurable in the field to operate with single-, double-, or triple-pole relay groupings.
    b. Configurable in the field to operate with normally closed or normally open behavior.
    c. Provides visual status of current state and manual override control of each relay.
    d. Listed for the following minimum ratings:
        1) 40A @ 120-480VAC Ballast
        2) 16A @ 120-277VAC Electronic
        3) 20A @ 120-277VAC Tungsten
        4) 20A @ 48VDC Resistive
        5) 2HP @ 120VAC
        6) 3HP @ 240-277VAC
        7) 65kA SCCR @ 480VAC
4. 0-10 dimming outputs shall support a minimum of 100mA sink current per output.
5. Relay and dimming outputs shall be individually programmable to support all standard sequence of operations as defined in this specification.
6. Panel shall be UL924 listed for control of emergency lighting circuits.
7. Panel shall power itself from an integrated 120-277 VAC or optional 347VAC supply.
8. Panel shall provide a configurable low-voltage sensor input with the following properties:
    a. Configurable to support any of the following input types:
        1) Indoor Photocell
        2) Outdoor Photocell
        3) Occupancy Sensor
        4) Contact Closure
    b. Low voltage sensor input shall provide +24VDC power for the sensor so that additional auxiliary power supplies are not required.
    c. Sensor input supports all standard sequence of operations as defined in this specification.
9. Panel shall provide a contact closure input that acts as a panel override to activate the normally configured state of all relays (i.e., normally open or normally closed) in the panel. This input is intended to provide an interface to alarm systems, fire panels, or BMS system to override the panel.
10. Panel shall supply current limited low voltage power to other networked devices connected via low voltage network cable.
11. Panel shall be available with NEMA 1 rated enclosure with the following properties:
    a. Surface-mounted or flush-mounted enclosure back box
    b. Screw-fastened cover or hinged cover with keyed lock
12. Panel shall be rated from 0-50C.

G. Wired Networked Communication Bridge
1. Product Series: LMBC
2. Device shall surface mount to a standard 4” x 4” square junction box.
3. Device shall have 8 RJ-45 ports for connection to lighting control zones (up to 127 devices per port), additional network bridges, and System Controller.
4. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to System Controller.
5. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply, or powered via low voltage network connections from powered lighting control devices (e.g. power packs).
6. Wired Bridge shall be capable of redistributing power from its local supply and connected lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.

PART 3 EXECUTION

3.01 WIRING INSTALLATION

A. Comply with NECA 1.

B. Installation Procedures and Verification
   1. The successful bidder shall review all required installation and pre-startup procedures with the manufacturer's representative through pre-construction meetings.
   2. The successful bidder shall install and connect the networked lighting control system components according to the manufacturer's installation instructions, wiring diagrams, the project submittals and plans specifications.
   3. The successful bidder shall be responsible for testing of all low voltage network cable included in the bid. Bidder is responsible for verification of the following minimum parameters:
      a. Wire Map (continuity, pin termination, shorts and open connections, etc.)
      b. Length
      c. Insertion Loss

C. Coordination with Owner's IT Network Infrastructure
   1. The successful bidder is required to coordinate with the owner's representative to secure all required network connections to the owner's IT network infrastructure.
      a. The bidder shall provide to the owner's representative all network infrastructure requirements of the networked lighting control system.
      b. The bidder shall provide to the manufacturer's representative all necessary contacts pertaining to the owner's IT infrastructure, to ensure that the system is properly connected and started up.
      c. Coordinate on creation of Virtual Server to host Enterprise Lighting Control Application if applicable.

D. Wiring Method:
   1. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
   2. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Division 27 Section "Communications Horizontal Cabling."
   3. Minimum conduit size shall be 1/2 inch.

E. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

F. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

G. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

H. Install dimmer cabinets for each zone, as required.

3.02 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" for identifying components and power and control wiring.

B. Label each dimmer module with a unique designation.

C. Label each scene control button with approved scene description.

3.03 SYSTEM STARTUP

A. Upon completion of installation by the installer, including completion of all required verification and documentation required by the manufacturer, the system shall be started up and programmed by an authorized representative of the manufacturer.
   1. Low voltage network cable testing shall be performed prior to system startup.

B. System start-up and programming shall include:

1. Verifying operational communication to all system devices.
2. Programming the network devices into functional control zones to meet the required sequence of operation.
3. Programming and verifying all sequence of operations.
4. Customization of owner’s software interfaces and applications.

C. Initial start-up and programming is to occur on-site. Additional programming may occur on-site or remotely over the Internet as necessary.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Continuity tests of circuits.
   2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
      a. Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
   3. Emergency Power Transfer: Test listed functions.

D. Remove and replace malfunctioning dimming control components and retest as specified above.

E. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

F. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain central dimming controls. Minimum 8 hours of training.

END OF SECTION

SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   1. Distribution transformers.

1.02 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

E. Energy-Efficient Transformers Rated 15 kVA and Larger: Certified as meeting NEMA TP 1, Class 1 efficiency levels when tested according to NEMA TP2.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.05 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
   2. Eaton Electrical Inc.; Cutler-Hammer Products.
   3. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
   4. General Electric Company.
   5. Siemens Energy & Automation, Inc.
   6. Sola/Hevi-Duty.
   7. Square D; Schneider Electric.

2.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Aluminum.

2.03 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Comply with NEMA TP-1 Energy Efficient @ 35% average loading.

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: ANSI 61 gray.

F. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class: 220, 115 degree C transformer shall be provided when the load factor is up to 50% of their capacity, otherwise, class 220C, 80 degree C rise shall be provided.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.
   3. Shield Effectiveness:
      a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.

b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

M. Wall Brackets: Manufacturer's standard brackets.

N. Vibration Isolation: Utilize neoprene mounts with a minimum static deflection of 0.30 inches, similar to Mason RCA for in shear wall mounts or Mason Super W resilient pads for floor mounted equipment.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

Q. Ground terminal bar per NEC 450.10. Bond to transformer enclosure.

2.04 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.05 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions applicable to Project. Construct concrete bases not less than 4 inches larger in both directions than supported unit and 4 inches high. Paint bases OSHA approved yellow.

3.03 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Infrared Scanning: Two months after Final Acceptance, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Final Acceptance.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 24 13 - SWITCHBOARDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

1.02 SUMMARY

A. Section Includes:
1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.03 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
1. Scaled layout of equipment within the project electric room.
2. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
3. Detail enclosure types for types other than NEMA 250, Type 1.
4. Detail bus configuration, current, and voltage ratings.
5. Detail short-circuit current rating of switchboards and overcurrent protective devices.
6. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
7. Detail utility company's metering provisions with indication of approval by utility company.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include schematic and wiring diagrams for power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Qualification Data: For qualified testing agency.

D. Field Quality-Control Reports:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. Include the following:
1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 891.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.06 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

1.07 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 18-months from date of Final Acceptance.

1.09 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

B. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Panel mounted.
   2. Branch Devices: Panel mounted.
   3. Sections front and rear aligned.

C. Nominal System Voltage: 480Y/277 V.

D. Main-Bus Continuous: As indicated on drawings.

E. Indoor Enclosures: Steel, NEMA 250, Type 1.

F. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

G. Barriers: Between adjacent switchboard sections.

H. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

I. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.

J. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

K. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated, with tin-plated aluminum or copper feeder circuit-breaker line connections.
2. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
3. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
5. Service Entrance switchboards shall be UL rated for 90^0 C for terminating 90^0C rated service entrance cables, including circuit breakers. Switchboard enclosure shall be vented.

L. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

M. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

N. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.02 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Surge Protection Device Description: Type 2, IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
10. Four-digit, transient-event counter set to totalize transient surges.

C. Peak Single-Impulse Surge Current Rating: 120 kA per mode/240 kA per phase.

D. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

E. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:
1. Line to Neutral: 800 V for 480Y/277.
2. Line to Ground: 800 V for 480Y/277.
3. Neutral to Ground: 800 V for 480Y/277.

2.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): For Feeder Breakers comply with UL 489, with interrupting capacity to meet available fault currents. Series ratings are not acceptable.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I^2t response.
   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
   6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
      c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
      d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
      f. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
      g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): For main circuit breaker, 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
   1. Circuit Breakers shall be UL rated for 900 C for terminating 900C rated service entrance cables.
   2. Fixed circuit-breaker mounting.
   3. Two-step, stored-energy closing.
   4. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time time adjustments.
      c. Ground-fault pickup level, time delay, and I^2t response.
   5. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   6. Remote trip indication and control.
   7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   8. Control Voltage: 120-V ac.

C. System Coordination: Overcurrent protection devices provided by the manufacturer on this project shall provide adequate time separation between devices installed in series so that the

closest device upstream of a fault condition will open and clear the fault prior to any other upstream overcurrent protection device operating.

1. This includes but is not limited to providing overcurrent protection devices with the same trip rating as shown on the drawings and equipped adjustable time current curve characteristics, shown or not shown on the drawings, that coordinate with other overcurrent protection devices that are in the same series circuit.
2. When installed all series connect overcurrent protection devices shall be coordinated in this manner.
    a. Exceptions: Selective coordination is not required between protective devices with the same trip rating or protective devices in series where the operation of either device would affect the same load.
3. Whenever trip ratings are required to be increased or decreased in order to coordinate with overcurrent devices that are in the same series circuit the cost of the adjusted trip rating/circuit breaker shall be included in the bid. This shall be brought to the attention of the Engineer prior to ordering the equipment.
    a. The engineer shall issue any required changes to feeder conductors due to trip rating adjustments for coordination purposes.

2.04 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
    1. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
    2. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
    3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
    1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
        a. Voltage (L-N) per phase.
        b. Voltage (L-L) per phase.
        c. Voltage (L-N) average.
        d. Voltage (L-L) average.
        e. Current per phase.
        f. Current average.
        g. Current Demand, Average + per phase.
        h. Current neutral.
        i. Energy (kWh) Imported.
        j. Energy (kWh).
        k. Power (kW) Total.
        l. Peak power demand (kW).
        m. Frequency.
        n. Power Factor Total.
        o. Power (kW) per phase.
        p. Power Factor per phase.
        q. Reactive Energy (KVARH).
        r. Apparent Energy.
        s. Reactive Power – per phase & total.
        t. Apparent Power – per phase & total.
        u. Reactive Power – Peak Demand.
        v. Apparent Power Peak Demand.
        w. THD Voltage & Current per Phase.

2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

2.05 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.06 IDENTIFICATION

A. Single Line Diagram: Upon completion of installation and prior to final inspection, the contractor shall obtain from the electrical engineer of record the “as-built” single line diagram or riser diagram, frame and provide two (2) diagrams mounted under glass, and mounted to the wall in locations as designated by the Owner.

PART 3 EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Specifications.
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

I. Installation of Sub Metering

1. All control power, CT, PT, RS485 and Ethernet data communications wire shall be field installed by System Installer.
2. All wiring required to connect equipment lineups shall be installed by the System Installer.
3. Contractor metering interconnection wiring requirements shall be clearly identified on the TMS network drawings, including standard product data sheets and typical wiring diagrams.
4. Coordinate with BAS Contractor after startup that IP connection can be established and provide BACnet points list.

J. Switchboards identified for use as service equipment shall be so labeled.

K. Upon completion of installation, and prior to final inspection, the contractor shall provide a reduced-size “as-built” single line diagram, framed under glass, and mounted in a conspicuous place adjacent to the main service switchboard.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:
1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
4. For services 1000 amperes or larger, the following tests shall be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. Prior to testing the contractor shall verify all circuit breaker settings with the Engineer of Record. All readings shall be tabulated.
    a. Phase tripping tolerance (within 20% of UL requirements).
    b. Trip time (per phase) in seconds.
    c. Instantaneous trip (amps) per phase.
    d. Insulation resistance (in megaohms) at 100 volts (phase to phase, and line to load).
5. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the Overcurrent Protective Device Coordination Study

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

3.06 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.07 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION

SECTION 26 24 16 - PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.02 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. SPD: Surge Protection Device.

1.03 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, surge protection device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Scaled layout of equipment within the project electric room.
   2. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
   3. Detail enclosure types and details for types other than NEMA 250, Type 1.
   4. Detail bus configuration, current, and voltage ratings.
   5. Short-circuit current rating of panelboards and overcurrent protective devices.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include wiring diagrams for power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.
   8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

F. Operation and Maintenance Data: For panelboards and components include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 18-months from date of Final Acceptance of the Work.

1.07 PROJECT CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

1.08 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or surge protection devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 18-months from date of Final Acceptance.

1.10 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Kitchen or Wash-Down Areas: NEMA 250, Type 4X.
      c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
      d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
   4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Galvanized steel.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
   7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses:
   1. Material: Hard-drawn copper, 98 percent conductivity.
   2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box 100% rated.
   3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
   4. Neutral Bus: 100 percent of phase bus.
   5. Split Bus: Vertical buses divided into individual vertical sections.

D. Conductor Connectors: Suitable for use with conductor material and sizes.
   1. Material: Hard-drawn copper, 98 percent conductivity.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
   4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rated panelboard are not acceptable.

H. Service entrance equipment must be third party SE rated.

I. Feed-thru panels are not permitted.

2.02 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Minimum Frame Sizes for Circuit Breaker Overcurrent Protection Device in Distribution Panelboards:
   1. Distribution Panelboards with 400-amp bus ratings shall be manufactured to accommodate, as a minimum, 3-pole 250-amp frame circuit breakers.
   2. Distribution Panelboards with 600-amp bus ratings shall be manufactured to accommodate, as a minimum, 3-pole 400-amp frame circuit breakers.
   3. Distribution Panelboards with 800-amp bus ratings shall be manufactured to accommodate, as a minimum, 3-pole 600-amp frame circuit breakers.
   4. Distribution Panelboards with 1200-amp bus ratings shall be manufactured to accommodate, as a minimum, 3-pole 800-amp frame circuit breakers.

G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

H. System Coordination: Overcurrent protection devices provided by the manufacturer on this project shall provide adequate time separation between devices installed in series so that the closest device upstream of a fault condition will open and clear the fault prior to any other upstream overcurrent protection device operating.
   1. This includes but is not limited to providing overcurrent protection devices with the same trip rating as shown on the drawings and equipped adjustable time current curve characteristics, shown or not shown on the drawings, that coordinate with other overcurrent protection devices that are in the same series circuit.
   2. When installed all series connect overcurrent protection devices shall be coordinated in this manner.

I. Branch Overcurrent Protective Devices: Fused switches.

J. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. System Coordination: Overcurrent protection devices provided by the manufacturer on this project shall provide adequate time separation between devices installed in series so that the closest device upstream of a fault condition will open and clear the fault prior to any other upstream overcurrent protection device operating.
   1. This includes but is not limited to providing overcurrent protection devices with the same trip rating as shown on the drawings and equipped adjustable time current curve characteristics, shown or not shown on the drawings, that coordinate with other overcurrent protection devices that are in the same series circuit.
      a. When installed all series connect overcurrent protection devices shall be coordinated in this manner. Exceptions: Selective coordination is not required between protective devices with the same trip rating or protective devices in series where the operation of either device would affect the same load.
   2. Whenever trip ratings are required to be increased or decreased in order to coordinate with overcurrent devices that are in the same series circuit the cost of the adjusted trip rating/circuit breaker shall be included in the bid. This shall be brought to the attention of the Engineer prior to ordering the equipment.
      a. The engineer shall issue any required changes to feeder conductors due to trip rating adjustments for coordination purposes.

F. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
   2. External Control-Power Source: 24-V control circuit.

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents. Series ratings are not acceptable.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I2t response.
   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   5. GFCI Circuit Breakers: Where shown on the drawings for receptacle circuits, provide Class A ground-fault protection (6-mA trip).

6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Where shown on the drawings for mechanical equipment provide Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
    g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
    h. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
    i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
    j. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
    k. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
    l. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on position.
    m. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
9. System Coordination: Overcurrent protection devices provided by the manufacturer on this project shall provide adequate time separation between devices installed in series so that the closest device upstream of a fault condition will open and clear the fault prior to any other upstream overcurrent protection device operating.
    a. This includes but is not limited to providing overcurrent protection devices with the same trip rating as shown on the drawings and equipped adjustable time current curve characteristics, shown or not shown on the drawings, that coordinate with other overcurrent protection devices that are in the same series circuit.
    b. When installed all series connect overcurrent protection devices shall be coordinated in this manner.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."
2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
3. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

2.05 SURGE PROTECTION DEVICES

A. Surge Protection Device: Type 3, IEEE C62.41-compliant, integrally mounted, wired-in or bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.
1. Accessories:

a. Retain accessories in first 10 subparagraphs below to coordinate with options retained in paragraph above; verify availability and compatibility with manufacturer.
   1) Fuses rated at 200-kA interrupting capacity.
   2) Fabrication using bolted compression lugs for internal wiring.
   3) Integral disconnect switch.
   4) Redundant suppression circuits.
   5) Redundant replaceable modules.
   6) Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   7) LED indicator lights for power and protection status.
   8) Audible alarm, with silencing switch, to indicate when protection has failed.
   9) Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   10) Six-digit, transient-event counter set to totalize transient surges.
   11) Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
   12) Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
   13) Line to Neutral: 70,000 A.
   14) Line to Ground: 70,000 A.
   15) Neutral to Ground: 50,000 A.
   16) Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
   17) Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 280Y/120, three-phase, four-wire circuits shall be as follows:
   18) Line to Neutral: 800 V for 480Y/277 400 V for 208Y/120.
   19) Line to Ground: 800 V for 480Y/277 400 V for 208Y/120.
   20) Neutral to Ground: 800 V for 480Y/277 400 V for 208Y/120.
   21) Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
   22) Protection modes and UL 1449 SVR for 208-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
   23) Line to Line: 2000V for 480 V 1000 V for 208 V.
   24) Line to Ground: 1500 V for 480 V 800 V for 208V.

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Specifications.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to panelboards.
   5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Mount top of trim 90 inches above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

F. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

G. Install filler plates in unused spaces.

H. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade. Provide pull wire and cap each spare conduit.

I. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

J. Comply with NECA 1.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. For services 1000 amperes or larger, the following tests shall be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. Prior to testing the contractor shall verify the circuit breaker settings with the Engineer of record. All readings shall be tabulated:
   a. Phase tripping tolerance (within 20% of UL requirements).
   b. Trip time (per phase) in seconds.
   c. Instantaneous trip (amps) per phase.
   d. Insulation resistance (in megaohms) at 100 volts (phase to phase, and line to load).
4. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the Overcurrent Protective Device Coordination Study.
5. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: Not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Final Acceptance.
   c. Instruments and Equipment:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

C. Load Balancing: After Final Acceptance, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.06 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 26 27 26 - WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Receptacles, receptacles with integral GFCI, and associated device plates.
   2. USB receptacles.
   3. Twist-locking receptacles.
   4. Snap switches and wall-box dimmers.
   5. Solid-state fan speed controls.
   6. Communications outlets.
   7. Pendant cord-connector devices.
   8. Retractable cord reels.
   9. Cord and plug sets.
   10. Charging Stations
   11. Floor service outlets, poke-through assemblies, service poles, and multi-outlet assemblies.
   12. Emergency power off (EPO) buttons.

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.05 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Floor Service Outlet Assemblies: One for every 10, but no fewer than one.
   2. Poke-Through, Fire-rated closure plugs: One for every five floor service outlets installed, but no fewer than two.
   3. SPD Receptacle: One for every 10 of each type installed, but no fewer than two of each type.

1.06 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   1. Cord and Plug Sets: Match equipment requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
   1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
   2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
   3. Leviton Mfg. Company Inc. (Leviton).
   4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.02 USB CHARGING RECEPTACLES

A. Products: Subject to compliance with requirements, provide one of the following:
   1. Pass & Seymour; TRE5362USB
   2. Hubbell; USB20A
   3. Leviton; T5632
   4. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
   5. USB Receptacles: Dual and quad, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
   6. Standards: Comply with UL 1310 and USB 3.0 devices.

2.03 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, Heavy-Duty, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; 5351 (single), 5352 (duplex).
   3. Hubbell; HBL5351 (single), CR5352 (duplex).
   4. Leviton; 5891 (single), 5352 (duplex).
   5. Pass & Seymour; 5381 (single), 5352 (duplex).
   6. Receptacles shall have side wired terminals with brass screws and hex ground screw.

2.04 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, Heavy-Duty, 125 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; GF20.
   3. Pass & Seymour; 2084.
   4. Leviton; W7899
   5. Hubbell; GFR5362

2.05 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, Heavy-Duty, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; L520R.
   3. Hubbell; HBL2310.
   4. Leviton; 2310.
   5. Pass & Seymour; L520-R.

B. Isolated-Ground, Single Convenience Receptacles, Heavy-Duty, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
2. Hubbell; IG2310.
3. Leviton; 2310-IG.
4. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.06 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
   1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
   2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.07 RETRACTABLE CORD REELS

A. Description: Matching type plug and receptacle body connector, NEMA WD 6 configurations 5-20P and 5-20R, heavy-duty grade.

B. Basis of Design: KH Industries RTB Series RTBB3L-WDD520-J12F
   1. Body: Steel construction with adjustable guide arm, ball stop, and slip ring rated for 600V/30A
   2. Adjustable ratcheting mechanism (locked or unlocked as needed)
   3. Output end shall include minimum of one 20A rated duplex receptacle.

2.08 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
   2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.09 TWO-GANG OUTDOOR CHARGING STATION WITH ACCENT LIGHT

A. Outdoor charging stations prewired with two devices and a 7W, 4000k LED accent light for easy identification at night. Power and lighting are prewired on separate circuits.
   1. Supplied with color-matched door that can be easily replaced by a color-matched locking door or a transparent door.
   2. Interior illuminates when door is open. Door closes automatically to meet while-in-use requirements.

B. Basis of Design: Wiremold Catalog No. XCSAL2GRU-[BK] with one (1) 20A weather-resistant GFCI and one (1) 4-port 4.2A USB outlets; powder coat finish, Black color.

C. Materials:
   1. Top Cap and Pedestal Body: 0.188-inch thick aluminum extrusion.
   2. Pedestal Base: Steel base with 4-1/4-inch [108mm] opening and four (4) 3/8-inch [9.5mm] diameter “L” bolts, eight inches [203mm] long.
   3. Shelves: 0.25-inch thick aluminum coated with outdoor-rated coating.
   4. Transparent Door: Polycarbonate; UL F1 rated to ensure UV resistance.
   5. Lenses: Polycarbonate; UL F1 rated to ensure UV resistance.
   6. Paint: Outdoor-rated powder coat.

D. Stub up conduit to a height of eight (8) inches for standard power installations.

2.10 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. All switches shall have quiet operating mechanisms without the use of mercury switches. All switches shall be listed by an “approved” third-party agency, approved for the voltage and amperage indicated. Self ground type is not acceptable. Switches shall have side wired terminals with brass screws and hex ground screw.

C. Switches, Heavy-Duty, 120/277 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
   3. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
   4. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
   5. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

D. Pilot Light Switches, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; 2221PL for 120 V and 277 V.
   3. Hubbell; HPL1221PL for 120 V and 277 V.
   4. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
   5. Pass & Seymour; PS20AC1-PLR for 120 V.
   6. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

E. Key-Operated Switches, Heavy-Duty, 120/277 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; 2221L.
   3. Hubbell; HBL1221L.
   4. Leviton; 1221-2L.
   5. Pass & Seymour; PS20AC1-L.
   6. Description: Single pole, with factory-supplied key in lieu of switch handle.

F. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; 1995.
   3. Hubbell; HBL1557.
   4. Leviton; 1257.
   5. Pass & Seymour; 1251.

G. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
   1. Products: Subject to compliance with requirements, provide one of the following:
   2. Cooper; 1995L.
   3. Hubbell; HBL1557L.
   4. Leviton; 1257L.
   5. Pass & Seymour; 1251L.

2.11 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Phase Dimming: Sinusoidal input power wave is modulated on a leading or trailing edge basis to reduce light output. (Triac forward phase or ELV reverse phase).

D. Analog 0-10V Dimming: Open dimming protocol in which the dimmer supplies a 0-10V control signal (control source) where 10 is full output and 1 is minimum dimming level of the dimmer/driver/ballast combination utilizing separate control wires.

2.12 COMMUNICATIONS OUTLETS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. Leviton
   2. Belden
   3. Hubbell
   4. Leviton
   5. Legrand

B. Faceplates:
   1. Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
   2. Plastic Faceplate: Smooth high-impact plastic. Coordinate color to match Electrical faceplates.
   3. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work-area cords.

2.13 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: 0.035-inch- thick, satin-finished 302 stainless steel.
   3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
   4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum or thermoplastic with lockable cover.

2.14 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Round die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Four modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable.

2.15 FLOOR BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. LeGrand/Wiremold RPSFB & RPSFB-OG series.
   2. Equal products by Hubbell, Leviton may be submitted for approval

B. Floor boxes for slab on grade:
   1. Floor Boxes: Rectangular dual service metal concrete floor box with a non-metallic top that permits for thick concrete pours between 4” to 6” thick.
   2. 6 1/16” high, 5 5/16” diameter top.
   3. Graduated markings on the inside and outside of the box indicating volume capacity and depth of concrete pour.
   4. Box shall accept 2HUB to allow 2” conduit feeds while maintaining 4” deep concrete pour.
   5. Provide reusable concrete cap.
   6. Conduit entry for:
   7. 2 sides with ¾” and 1 ¼” KO each side.
   8. 2 sides with 1” KO each side.
   9. Bottom: Two 1 ½” KO.

2.16 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Legrand (Evolution Series) 6AT, 8AT.
2. Hubbell Incorporated; Wiring Device-Kellems.
3. Wiremold Company (The).

B. Description: Factory-fabricated and pre-wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
1. Service Outlet Assembly: Recessed with minimum two duplex receptacles and space for four RJ-45 jacks.
2. Size: Selected to fit nominal 6-inch or 8-inch cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, 4-pair, Category 6 voice and data communication cables.
6. Wiremold: 6AT and 8AT or equal by manufacturers listed above.
7. Where power and data service required, provide 6-inch device.
8. Where power, data and A/V service required, provide 8-inch device.

2.17 MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold Company (The).
3. Legrand

B. Basis of Design: Wiremold 2000 Series.

C. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

D. Raceway Material: Metal, with manufacturer's standard finish.

E. Provide outlets 12” on center for length of assembly.

F. Wire: No. 12 AWG.

2.18 EMERGENCY POWER OFF (EPO) BUTTONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Safety Technology International.
2. E Technologies Inc.
3. Hubbell.

B. Basis of Design: Safety Technology International SS2042PO-EN.

C. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways.

D. Actuator: Red mushroom pushbutton; key-to-reset.

E. Indoor/outdoor rated flush cover with audible horn.

F. Label Text: White letters “EMERGENCY POWER OFF”.

G. Finish: Red

2.19 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.
1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

PART 3 EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
   5. Cut back and pigtail, or replace all damaged conductors.
   6. Straighten conductors that remain and remove corrosion and foreign matter.
   7. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
   1. Install dimmers within terms of their listing.
   2. Verify that dimmers used for fan speed control are listed for that application.
   3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

4. Dimming switches shall be provided such that dimming protocol is compatible with luminaire drivers, ballasts, power supplies or light engines specified or provided for each space or control zone as indicated on drawings.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
   1. Wall switches and Receptacles: Identify panelboard and circuit number from which served.
   2. Label all cover plates using adhesive film label with clear protective overlay.
      a. Labels shall include the power source panelboard name and circuit number. Example: “Panel 1NL2-24”
      b. Labels shall be placed below the toggle on wall switches and below the lower duplex receptacle on receptacles.
   3. For wall switches and/or receptacles connected to generator circuits provide engraved stainless steel cover plate with the text “EMERGENCY” using ¼” high red filled letters.
      a. Engraved text shall be located above toggle on wall switches and above the upper receptacle for receptacles.
   4. Provide durable wire markers or tags inside outlet boxes.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

END OF SECTION

SECTION 26 28 13 - FUSES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, and enclosed controllers.
   2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches and fuseholders.
   3. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
   4. Spare-fuse cabinets.

B. This section includes power fuses rated above 600-V ac for use in switchgear.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   3. Current-limitation curves for fuses with current-limiting characteristics.
   4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
   5. Coordination charts and tables and related data.
   6. Fuse sizes for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: Include the following:
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics.
   3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
   4. Coordination charts and tables and related data.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.04 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.05 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.06 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussmann, Inc.
   2. Edison Fuse, Inc.
   3. Ferraz Shawmut, Inc.
   4. Littelfuse, Inc.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.03 PLUG FUSES

A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.04 PLUG-FUSE ADAPTERS

A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

2.05 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
   4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 600 VOLT AND LESS FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Service Entrance: Class RK1, time delay.
   2. Feeders: Class RK1, time delay.
   3. Motor Branch Circuits: Class RK1, time delay.

4. Other Branch Circuits: Class RK1, time delay.
5. Control Circuits: Class CC, fast acting.

B. Plug Fuses:
1. Motor Branch Circuits: Edison-base type, dual-element time delay.
2. Other Branch Circuits: Edison-base type, single-element fast acting.

3.03 15 KV – SOLID MATERIAL POWER FUSES

A. Fuses shall be disconnect style, solid-material power fuses, and shall utilize refill-unit-and-holder or fuse-unit-and-end-fitting construction. The refill unit or fuse unit shall be readily replaceable and low in cost.

B. Fusible elements shall be non-aging and non-damageable so that it is unnecessary to replace unblown companion fuses on suspicion of damage following a fuse operation.

C. Each refill unit or fuse unit shall have a single fusible element to eliminate the possibility of unequal current sharing in parallel current paths.

3.04 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.

C. Install spare-fuse cabinet(s).

3.05 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Molded-case circuit breakers.
   4. Molded-case switches.
   5. Enclosures.

1.02 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. HD: Heavy duty.

C. RMS: Root mean square.

D. SPDT: Single pole, double throw.

1.03 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current rating.
   4. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

B. Shop Drawings: Diagram power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Qualification Data: For testing agency.

D. Field quality-control test reports including the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Manufacturer's field service report.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current curves, including selectable ranges for each type of circuit breaker.
   3. Routine maintenance requirements for components.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70. Comply with NEMA AB 1 and NEMA KS 1.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet.

1.06 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.07 MAINTENANCE MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spares: For the following:
      a. Potential Transformer Fuses: Six.
      b. Control-Power Fuses: Six.
      c. Fuses and Fusible Devices for Fused Circuit Breakers: Six.
      d. Fuses for Fusible Switches: Six.
      e. Fuses for Fused Power Circuit Devices: Six.
   2. Spare Indicating Lights: Six of each type installed.

PART 2 PRODUCTS

2.01 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:
   1. Eaton Corporation; Cutler-Hammer Products.
   2. General Electric Co.; Electrical Distribution & Control Division.
   3. Siemens Energy & Automation, Inc.
   4. Square D/Group Schneider.

B. Fusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Nonfusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

D. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
   3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.
      a. Provide auxiliary contact kit for each fusible disconnect switch located in the elevator machine room feeding a hydraulic elevator motor.
      b. Provide auxiliary contact kit for all disconnect switches.

2.02 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:
   1. Eaton Corporation; Cutler-Hammer Products.
   2. General Electric Co.; Electrical Distribution & Control Division.
   3. Siemens Energy & Automation, Inc.
   4. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I^2t response.
   4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
   5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
   6. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
   4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

E. Molded-Case Switch Accessories:
   1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
   2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
   3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
   4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay. Provide "dummy" trip unit where required for proper operation.

5. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
6. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.03 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
   1. Outdoor Locations: NEMA 250, Type 3R.
   2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2.04 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard gray paint applied to factory-assembled and -tested enclosures before shipping

2.05 RESIDUAL CURRENT DEVICE

A. Specifications
   1. Design according to IEC / EN 61008.
   2. Certifications: VDE, CE Marked
   3. Tripping Time: Undelayed; 40 ms for “D” Suffix
   4. Rated Voltage: 230 / 400V, 50 Hz
   5. Rated Tripping Current: 30, 100, 300, 500 mA
   6. Sensitivity: AC and Pulsating DC
   7. Rated Short Circuit Capability
      a. 10 kA with 63 A gG / gL Back-Up Fuse for up to 63 A
      b. 10 kA with 80 A gG/ gL Back-Up Fuse for 80 A
   8. Maximum Back-Up Fuse for Short Circuit Protection
      a. 63 A gG / gL for up o 63 A
      b. 80 A gG / gL for 80
   9. Maximum Back-Up Fuse for Overload Protection
      a. 25 A gG / gL (25 A and 40 A devices)
      b. 40 A gG / gL (63 A device)
      c. 50 A gG / gL (80 A device)
   10. Resistance to Climatic Conditions: Per IEC / EN 61008
   11. Degree of Protection: Built-in switch IP40
   12. Electrical Life: ≥ 4000 change-overs
   13. Mechanical Life: ≥ 10000 change-overs
   14. Mounting: DIN Rail
   15. Housing Material: Halogen-Free
   16. Electrical Life: ≥ 4000 change-overs
   17. Operating Temperature: -25° C...+40° C (Non-Condensing)
   18. Shipment and Short-Term Storage Limits: -35° C…+60° C
   19. Wire Size: 1.5…35mm² Copper
   20. Terminal Torque: 2.4 N•m ≤ 40 A, 3.0 N•m ≥ 63 A
   21. Recommended Wire Strip Length: 13 mm
   22. Verify ampere trip ratings with drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

3.03 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Mount individual wall-mounted switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounted switches to concrete base.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Provide 2#12, 1#12 ground, ½"C minimum from elevator disconnect switch auxiliary contact to the elevator controller. Coordinate with elevator installer and terminate the conductors at the disconnect switch on either the Normally Open or Normally Closed contact as instructed by the elevator installer.

E. Residual Current Devices: Provide DIN mounting rail in NEMA 4x weather enclosure for mounting the Residual Current Device.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:
   1. Inspect mechanical and electrical connections.
   2. Verify switch and relay type and labeling verification.
   3. Verify rating of installed fuses.
   4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
   5. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
   6. Test continuity of each line- and load-side circuit

B. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.06 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges. Verify settings with Engineer of record.

3.07 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION

SECTION 26 31 00 – PHOTOVOLTAIC POWER GENERATING SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fully operational, photovoltaic, electric generating system.
   2. All circuit breakers, disconnects and hardware required by NEC 2020, Article 690.

1.02 DEFINITIONS

A. Array: A mechanically-integrated assembly of modules and panels, together with support structure and other components, if used, to form a DC power-producing unit.

B. Azimuth angle: For a surface such as a sloped roof, project a line that extends perpendicular from the roof onto a horizontal plane. The angular deviation of this projection from the local meridian (north-south tine) constitutes the surface azimuth angle. Due south is zero azimuth, west of south is assigned as positive, and east of south is assigned as negative.

C. Insolation: Sunlight, direct and/or diffuse (not to be confused with insulation). The integrated intensity of sunlight reaching a given area, usually expressed in watts per square meter per day. This measurement may be used to express the average amount of solar energy falling on different regions of the country.

D. Magnetic declination: The difference between true north (the axis around which the earth rotates) and magnetic north (the direction the needle of a compass will point).

E. Module: A number of solar cells connected together electrically and sealed inside a weatherproof package with a clear face. Sometimes called a “solar panel”.

F. Panel: A designation for a number of PV modules assembled in a single mechanical frame.

G. Photovoltaic: Pertaining to the direct conversion of light into electricity.

H. PTC (PVUSA Test Conditions): Test conditions applied to PV modules intended to represent wattage during operation. Irradiance of 1000 W/m2, 68 degrees F.

I. Ambient temperature, 1 meter/second wind speed, and an air mass of 1.5.

J. String: A number of modules or panels interconnected electrically in series to produce the operating voltage required by the load.

K. STC (Standard Test Conditions): Test conditions applied to PV modules. Irradiance of 1000 W/m2, cell temperature of 25 degrees C and an air mass of 1.5.

L. Tilt Angle: The angle of inclination of a solar panel measured from the horizontal plane.

M. Utility-Interactive Inverter: An inverter that can function only when electrically connected to the utility grid, and uses the prevailing line-voltage frequency on the utility line as a control parameter to ensure that the photovoltaic array’s DC output is converted to AC power and fully synchronized with the utility power.

1.03 SYSTEM DESCRIPTION

A. Requirements:
   1. Contractor is responsible for providing the fully functional PV system, including inverters.
   2. The PV system shall be designed to fit on the available roof area and meet the clearance requirements to the roof edges to eliminate the need for guard rails and other fall protection systems.
   3. The PV system shall be designed to not interfere with the building’s daylighting systems.
   4. Contract Drawings are diagrammatic and are intended to establish basic dimension of units, sight lines, and profiles of units.
   5. Provide details for attachment, fastening, penetrations, and electrical connections.
   6. Provide concealed fastening wherever possible.

7. Provide weather-tight penetrations of building envelope for structural and electrical connections.
8. Attachment considerations shall take into account site peculiarities and expansion and contraction movements so there is no possibility of loosening, weakening, or fracturing connection between PV system and building envelope components.
9. Comply with roof system manufacturer's warranty design criteria when penetrating or attaching to roof system.

B. Performance requirements:
1. PV system layout shown on drawings and Electrical Riser Diagram are diagrammatic and show minimum system requirements.
2. Provide estimate of system power production. AC kWh energy production shall take into consideration system losses, including but not limited to wire losses, fault protection losses, inverter efficiency, and system component degradation over life expectancy of system.
3. AC kWh energy production estimation shall utilize one of the following web sites or software programs or equal:
   a. PV Watts: http://www.nrel.gov/rredc/pvwatts/grid.html
   b. RETScreen® International: http://www.retscreen.net/ang/home.php
   c. PV Design Pro: www.mauisolarsoftware.com
   d. PVSYST: www.pvsyst.com
4. Standard photovoltaic modules shall produce no less than 80 percent of minimum rated power during first 20 years of service.

C. Interface with building systems:
1. PV system AC connection point: 480V, 3-phase, 4-wire (plus ground).
2. Data transmission means: RS485, Ethernet IP.
3. Interface with BAS system using Modbus RTU.
   a. Supplier must provide a Registry of data points available on the system.

1.04 SUBMITTALS

A. Product Data:
1. Submit product data for photovoltaic system components including but not limited to the following list:
   a. Include information for factory finishes, hardware, glass treatment, sealants, grounding, accessories, and other required components.
   b. Inverters
   c. Fuse boxes

B. Shop Drawings:
1. Submit shop drawings covering fabrication, installation, and finish of specified systems.
   a. Fully dimensioned plans and elevations with detail coordination keys.
   b. Electrical and structural penetration details of weather-tight building envelope.
   c. Locations and types of exposed fasteners and joints.
   d. Wiring diagrams.
   e. Single line diagrams.
   f. Rough-in requirements.

C. Closeout Submittals
1. Operation and Maintenance Data: Submit manufacturer's printed, recommended operation and maintenance data.
2. Warranty: Submit specified product warranty.

1.05 QUALITY ASSURANCE

A. Single Source Responsibility: To ensure quality of appearance and performance, obtain equipment for systems from single photovoltaic system installer or from manufacturers approved by photovoltaic system installer.

B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum 5 years documented experience.

C. Installer Qualifications: 5 years design and installation of commercial experience, and proper licensing.

D. Regulatory Requirements:
   1. Provide system meeting requirements of National Electric Code (NEC).
   2. Provide system meeting requirements of federal, state, and local building codes.

E. Certifications: Submit system component manufacturer's certification that products furnished for Project meet or exceed specified requirements.

1.06 PRE-INSTALLATION CONFERENCE

A. Conduct pre-installation conference after providing submittals but before beginning any installation.

B. Review requirements of Contract Documents and submittals.

C. Review anchor and weather-tight installation requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect finished surfaces as necessary to prevent damage.

B. Do not use adhesive papers or sprayed coatings that become firmly bonded when exposed to sun.

C. Do not leave coating residue on any surfaces.

D. Replace damaged units.

1.08 PROJECT CONDITIONS

A. Environmental Requirements:
   1. Do not install system during rain, snow, or windy conditions.
   2. Work on a dry roof only.

1.09 WARRANTY

A. Contractor shall warranty all products and installation for a period of 5 years from the date of final acceptance by the Owner.

B. Furnish Standard PV modules and panel components provided manufacturer's limited warranty of 25 years minimum.

C. Furnish DC to AC inverters covered by manufacturer's warranty for minimum of 5 years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design PV Module Manufacturers: QCells – 430 watt 144 cell mono-crystalline
   1. Approved Equal:
      a. Suntech Power Holdings Co., Ltd.
      b. Trina Solar Co., Ltd.

B. Basis of Design Inverter Manufacturers: Solectria PVI60TL-480
   1. Approved Equal:
      a. Fronius 1G Plus 6.0~1uni.
      b. SMA America Sunny Boy 600DUS
      c. Xantrex GT 6.0
      d. Solar Edge

2.02 REQUIRED EQUIPMENT

A. PV modules
   1. Shall be new, undamaged, fully warranted without defect.

2. Listed to UL 1703
3. Maximum Power: 450W
4. Open Circuit Voltage: 40V
5. Maximum Power Point Voltage: 32.6V
6. Module Efficiency: 17.89%
7. Monocrystalline PERC Cell type.
8. Tempered safety glass with ARC front.
9. Black anodized aluminum frame.
10. IP65 junction boxes.
11. Nominal Dimensions: 65.95”x39.4”x1.3”

B. DC to AC Inverter
1. Sized to provide maximum power point tracing for voltage and current range expected from photovoltaic array for temperatures and solar insolation conditions expected for Project conditions.
2. Listed to UL 1741. Each inverter is constructed with “anti-islanding” feature to de-energize inverter upon loss of utility voltage at input panel.
3. AC output voltage of 480V, three phase.
4. Inverters must be capable of providing 277V per phase to support 480/277V, 3 phase, 4 wire, grounded “wye” panelboards.

C. Mounting System:
1. PV Module Racking System:
a. Module racking system shall utilized framed PV modules.
b. Metal framed PV modules shall be grounded in conformance with electrical codes.

D. AC Disconnect Switch
1. Coordinate with local electric utility service provider requirements.
2. Provide switch to disconnect ungrounded AC conductors.
3. Lockable, gang operated type, clearly indicating open and closed positions.
4. Easily visually inspected to determine that switch is in open or closed position and clearly labeled in compliance with NEC and local electric utility service provider requirements.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify items provided by other Sections of work are properly sized and located.

B. Examine supporting members to ensure surfaces are at proper elevation and are free from dirt of other deleterious matter.

3.02 INSTALLATION

A. Locate PV array as shown on Drawings and approved shop drawings.

B. Install photovoltaic system in accordance with NEG, manufacturer’s printed instructions, electric utility service provider requirements, and approved shop drawings.

C. Install PV modules and DC to AC inverters with sufficient clearance to allow for proper ventilation and cooling.
1. Comply with manufacturer’s clearance recommendations if applicable.

D. Preferred installation required operational PV modules in location and manner to ensure maximum unobstructed, direct sun exposure.

E. Provide suitable means to secure attachments to mounting surfaces and structures where applicable.

F. Anchors, fasteners and braces shall be structurally stressed not more than 50% of allowable stress when maximum loads are applied.

G. Allow for expansion and contraction due to thermal changes and structural movement without detriment to appearance or performance.

H. Installer shall verify that work conditions are adequate and proper for installation.

I. Conductors routed above roof membrane shall be derated in accordance with NEC table.

3.03 ADJUSTING

A. Test and adjust operating functions in accordance with manufacturer's instructions to ensure smooth operation.

3.04 CLEANING

A. Clean surfaces in compliance with manufacturer's recommendations; remove excess mastic, mastic smears, foreign materials, and other unsightly marks.

B. Clean metal surfaces exercising care to avoid damage.

C. Clean energy generating surfaces of the PV module to ensure no obstructions block sunlight.

3.05 ACCEPTANCE TESTING

A. Acceptance Testing:
   1. To be provided by Contractor/Installer.
   2. Prior to testing ensure PV system has passed and received final inspection certificate from authorities having jurisdiction.
   3. Provide training to designated Owners representative.
      a. Training shall cover operation and maintenance of PV Modules and DC to AC converters including full operating cycle, troubleshooting techniques, and safety procedures.
   4. Ensure the installation has been performed in accordance with NEC and other local codes. Following NEC articles refer to PV systems:
      a. Article 690: Solar Photovoltaic Systems
      b. Article 230: Service Equipment – Disconnecting Means.
      c. Article 240: Overcurrent Protection.
      d. Article 250: Grounding
      e. Article 300: Wiring Methods
      f. Article 310: Conductors for General Wiring
      g. Article 705: Interconnected Electric Power Production Sources
   5. Refer to commissioning requirements contained within IEEE 1547.1 Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.
   6. Provide suitable tools and equipment for commissioning.
   7. Utilize System Commissioning Check sheet / Log sheet included below.

3.06 PROTECTION

A. Protect finished work from the date of installation until the date of final acceptance.

SYSTEM ACCEPTANCE TESTING CHECK SHEET / LOG SHEET

DATE & TIME: _____

WEATHER (SUNNY, CLOUDY, RAIN, ETC.):
_____

AIR TEMPERATURE (°F OR °C):
_____

MODEL BACKSKIN TEMPERATURE (°F OR °C):
_____

IRRADIANCE AT PLANE OF ARRAY (W/M2):
_____

SOURCE CIRCUIT	DC OPEN CIRCUIT VOLTAGE (350-600 VOLTS)	DC SHORT CIRCUIT CURRENT (0-8.0 AMPS)*	POSITIVE TO GROUND RESISTANCE (M-OHMS)	NEGATIVE TO GROUND RESISTANCE (M-OHMS)
STRING #1				

NOTES:

§ WARNING: MAKE CERTAIN THE DIGITAL VOLTAGE METER YOU ARE USING IS RATED FOR 600 VOLTS DC MINIMUM, CALIBRATED WITH CERTIFICATION (TRACEABLE), AND IS IN GOOD WORKING ORDER.

* NOTE: MOST HANDHELD DIGITAL MULTIMETERS HAVE THE CAPABILITY TO MEASURE A MAXIMUM OF 10 AMPS DC SHORT CIRCUIT CURRENT. A QUALITY MULTIMETER WILL HAVE A FUSE IN LINE IN ORDER TO PROTECT ITSELF. HOWEVER, DO NOT ELECTRICALLY SHORT A SOLAR MODULE OR PANEL IF YOU SUSPECT ITS OUTPUT TO BE GREATER THAN 10 AMPS. DC CURRENT CLAMP METERS ARE READILY AVAILABLE IN THE MARKET.

END OF SECTION

SECTION 26 32 14 - ENGINE GENERATORS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes packaged engine-generator sets for emergency power supply with the following features:
   1. Natural Gas engine.
   2. Unit-mounted cooling system.
   3. Unit-mounted control and monitoring.
   4. Performance requirements for sensitive loads.
   5. Outdoor enclosure.

B. Related Sections include the following:
   1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.02 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.03 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
   1. Thermal damage curve for generator.
   2. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
   2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators.
   3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
   4. Wiring Diagrams: Power, signal, and control wiring.
   5. Maintenance platform detailed construction.
   6. Circuit breakers installed at the generator.

C. Qualification Data: For installer, manufacturer, and testing agency.

D. Source quality-control test reports.
   1. Certified summary of prototype-unit test report.
   2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
   3. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   4. Report of sound generation.
   5. Report of exhaust emissions showing compliance with applicable regulations, including EPA requirements.
   6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For packaged engine generators include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.

B. Manufacturer Qualifications: The engine generator supplier shall maintain 24 hour parts and service capability within 100 miles of the project site. The distributor shall stock parts as needed to support the generator set package for this specific project. The distributor shall carry sufficient inventory to cover no less than 80% of the parts service within 24 hours and 95% within 48 hours.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASME B15.1.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

J. Comply with NFPA 111.

K. Comply with UL 2200.

L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

N. The emergency generator must be in compliance with all applicable requirements of 40 CFR Part 60 Subpart IIII.
1. The engine will be provided along with manufacturer certification of compliance with pertinent emission limits.

1.05 PROJECT CONDITIONS.

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
1. Ambient Temperature: 5 to 40 deg C.
2. Altitude: Sea level to 1000 feet.

1.06 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases.

1.07 WARRANTY

A. Special Warranty: Five Year Standby Generator Set Warranty
   1. The manufacturer's standard warranty shall in no event be for a period of less than Five (5) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall be limited to 500 hours annually for the system warranty by both the manufacturer and servicing distributor. Submittals received without written warranties as specified will be rejected in their entirety.
   2. Warranty shall include a temporary generator set in the event a warrantable repair will take more than 48 hours. Selling dealer must have a minimum of 100 units in its rental fleet to assure a temporary unit is available if needed. Provide documentation as such.

1.08 DOCUMENTATION AND TRAINING

A. Documentation: Prior to Final Acceptance, the manufacturer shall supply three (3) copies of the complete instruction manuals to Owner. The manuals shall include operation and maintenance procedures, complete parts lists, dimensional drawings, and unit wiring diagrams and schematics, and interconnection wiring diagrams.

B. Training: Prior to Final Acceptance, the manufacturer shall provide comprehensive training to the Owner’s designated personnel. Training shall cover, but not be limited to, operation, maintenance and troubleshooting of the equipment.

1.09 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Final Acceptance, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 MAINTENANCE MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
   2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
   3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Caterpillar; Engine Div.
   2. Generac Power Systems, Inc.
   3. Onan/Cummins Power Generation; Industrial Business Group.

2.02 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
   1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated herein, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Output Connections: Three-phase, four wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components.

D. Generator-Set Performance:
1. Steady-State Voltage
2. Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 15 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
4. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
7. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
9. Below requires 10-second maximum start time under specific conditions and includes startup only, not load assumption.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.
    a. This generator will be used to provide emergency standby power for egress lighting. The transfer switch and generator system shall provide rated voltage and frequency to the egress lighting system within 10-seconds from the time the normal power source to the transfer switch has been de-energized. For generators fueled by natural gas or propane, any required gas purge cycle shall be accounted for and included in this 10-second requirement.

2.03 ENGINE

A. Fuel: Natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:
1. Natural Gas System:
    a. Carburetor.
    b. Secondary gas regulator.
    c. Fuel shutoff solenoid valve.
    d. Flexible fuel connector.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Minimum coolant temperature shall not be less than 120 degrees F.

G. Governor: Adjustable isochronous, with speed sensing. Steady state operating band shall be within 2%. The generator controls shall accommodate harmonic distortion within the criteria of IEEE 519.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
   1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
   3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
   4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
   5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
      a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
      b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

I. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
   1. Configuration: Vertical air discharge.
   2. Radiator Core Tubes: Aluminum.
   3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
   4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
   5. Fan: Driven by multiple belts from engine shaft
   6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

J. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   1. Minimum sound attenuation specified below in sound attenuation.
   2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.
   3. The exhaust silencer outlet shall be terminated with a tailpipe (45 degree cut) or an exhaust elbow and ran cap and directed away from buildings and pedestrian pathways.

K. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

L. Starting System: 24-V electric, with negative ground.
   1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
   2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
   3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least two times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Automatic, solid-state, current limiting, float/equalizing battery charger. Unit shall comply with UL 1236 and include the following features:
    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent. Equipped with overload protection and voltage surge suppressors.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.04 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
    1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
    2. Current and Potential Transformers: Instrument accuracy class.

C. Indicating and Protective Devices and Controls as required by NFPA 110 for Level 1 system, and the following:
    1. AC voltmeter.
    2. AC ammeter.
    3. AC frequency meter.
    4. DC voltmeter (alternator battery charging).
    5. Engine-coolant temperature gage.

6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Generator overload.

D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

E. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.
6. Ground Fault Indication for circuit protective devices 150-volts or greater to ground and rated at 1,000-amps or more. Comply with NEC 700.7.

F. Remote Alarm Annunciator: An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

G. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
1. Provide two (2) remote Emergency-Stop Switches.
a. Install at locations as shown on the plans.
2. Switches shall be weather proof type.

H. BAS interconnection: Provide a BACnetIP output to the building BAS system that will send an alarm to the central campus control system whenever the generator is running.

I. Fire Alarm interconnection: Provide a output to the building Fire Alarm system that will send a supervisory alarm to the fire alarm control panel whenever the generator is running.

2.05 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.

4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

B. Load Shed Control: Upon generator overload, generator shall signal the lowest priority automatic transfer switch to switch to the neutral position.
   1. Provide the necessary control panel and internal logic circuit boards to monitor the generator load and/or frequency.
   2. Provide the necessary connections to the Automatic Transfer Switch(es) to perform the load shed based upon the generator overload condition.
   3. Provide all necessary conduit and wiring for this control function.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.06 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Drip proof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
   1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Subtransient Reactance: 12 percent, maximum.

2.07 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or pre-engineered reach-in enclosure with the following features:
   1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
   2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
   3. Space Heater: Thermostatically controlled and sized to prevent condensation.
   4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
   5. Radiator Exhaust air shall be deflected 90-degrees upward using a screened hood.
   6. Hinged Doors: With padlocking provisions.
   7. Ventilation: Intake equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
   8. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
   9. Muffler Location: Within enclosure.

10. Sound attenuated to 85 dBA or less as measured 10-ft. from any exterior wall surface of the generator set enclosure.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at standby rating with ambient temperature at top of range specified in system service conditions.
   1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

D. Interior Lights with Switch: Factory-wired, vapor-proof-type fixtures within housing; arranged to illuminate controls and accessible interior. Connected from the factory to the supplied load center panel.
   1. Provide one (1) dedicated 120-volt lighting circuit from an interior panelboard and connect to the lighting fixture.
   2. AC lighting system and connection point for operation when remote source is available.
   3. DC lighting system for operation when remote source and generator are both unavailable.

E. Convenience Outlets: Provide a minimum of 1 GFCI receptacle, factory mounted.
   1. Provide one (1) dedicated 120-volt circuit from an interior panelboard and connect to the generator receptacle.

F. Sound attenuation:
   1. The entire enclosure except for the louvered openings shall have sound attenuation material mechanically attached to the interior surfaces of the unit.
   2. The sound absorption material shall be held in place by a perforated galvanized metal sheeting to form a removable section easily inspected by maintenance personnel.
   3. The sound attenuation material and fastening system shall apply to the enclosure roof as well as the side panels and doors.
   4. The enclosure package shall be designed to achieve an 86.5dBa sound rating when measured at a distance of 23 feet, free field.

G. Base and mounting:
   1. The generator set and enclosure shall be mounted and shipped to the jobsite on a common structural steel sub-base. Provisions for crane unloading of the complete package shall be designed into the base of the unit.
   2. The base and enclosure assembly shall allow room within the package to mount and maintain the specified battery charger, engine starting batteries, racks, and cables, generator mounted mainline circuit breaker(s), an engine/generator control panel, and other items as specified or as shown on the drawings.
   3. The entire unit consisting of generator set, base, enclosure, and all other specified items including all liquids (i.e., fuel oil, lube oil and cooling water) shall be calculated by the manufacturer. The base of the unit shall be engineered, designed, and manufactured as a heavy duty, welded steel construction with four (4) point lifting provisions as used on heavy duty construction installations.
   4. Details and manufacturer’s certification of the base construction shall be included with the drawings submitted for approval.

H. Enclosure flooring:
   1. The floor of the enclosure shall be designed and constructed in such a manner as to prevent the entrance of rodents. This may be accomplished with solid metal or expanded metal grating but, in any event, shall be capable of supporting any ancillary equipment specified which may be secured to it (such as batteries, day tanks, etc.) plus the anticipated weight of maintenance personnel and their tools.
   2. Under no circumstances shall the floor area or any of its parts be considered for cooling air intake or discharge requirements of the generator set or its associated equipment, nor shall its properties as a “heat sink” or heat dissipating medium be utilized in any manner whatsoever in this application.

2.08 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
   1. Material: Natural rubber.
   2. Durometer Rating: 30.
   3. Number of Layers: Four.

2.09 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
   1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
   1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
   2. Full load run.
   3. Maximum power.
   4. Voltage regulation.
   5. Transient and steady-state governing.
   6. Single-step load pickup.
   7. Safety shutdown.
   8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
   9. Report factory test results within 10 days of completion of test.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases.

D. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger. Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

E. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
   1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

F. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.
   1. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 23 Section "Facility Natural-Gas Piping."

F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 as specified here including, but not limited to:
      a. 100% load test of the generator. This test is designed to determine that the generator system will deliver full load output as connected at the site. Typically, this test is performed prior to the building load testing and before final terminations of the emergency system conductors. The test shall be as follows:
         1) Generator load Bank Test:
            a) The generator shall be subjected to a three-hour test using resistive load bank with a 1.0 power factor. This test shall be performed at the job site in the presence of the Engineer. The contractor shall provide the resistive load bank to test the generator.
            b) One hour at 50% load.
            c) One hour at 75% load.

d) One hour at 100% load.
e) Upon completion of the three-hour load test, the generator shall be shut-down after the cooling period. The generator shall be started and immediately upon reaching rated rpm, 100% load shall be applied to demonstrate one-step full load capability. The capability of the system to pick up full standby service load within 10 seconds of power outage shall be demonstrated.

2) The following shall be recorded every thirty minutes during the load bank testing:
a) Engine water temperature.
b) Oil pressure.
c) Voltage per phase and neutral.
d) Amperes per phases and neutral.
e) Frequency, KW, KVA, and power factor.
f) Room or outdoor ambient temperature.

b. Building load test. Prior to occupancy, provide a load bank and test the generator system per the requirements of NFPA-110. The test essentially determines that the generator system will automatically detect a power loss, automatically start, automatically switch the designated load to the generator in the specified time frame and power the building load for two hours. The load test utilizing the simulated building loads and the observation and recording of load changes and the resultant effect on the voltage and frequency shall be a minimum duration of 2 hours of generator run time. A total time of 3-hours shall be allotted for the testing period. The tests shall be as follows:
1) With the prime mover in a “cold start” condition and the emergency load at standard operating level, a primary power failure shall be initiated by opening the switch or breaker supplying the primary power to the building or facility. The test load shall be the load that the emergency generator serves.
2) Observe and record the following during building load testing of the generator:
a) If the facility is equipped with a fire pump, the pump shall be energized and running for the initial 5-minute period of the load test, then the pump can be de-energized while the testing is in progress.
b) The time delay starting of the generator.
c) The cranking time until the prime mover starts and run.
d) The time that the generator reach the operating speed.
e) The time that the generator achieved steady-condition after the transfer switches transferred to the emergency position.
f) The generator voltage, frequency, amperes, prime mover oil pressure, and water temperature.
g) The battery charge rate shall be recorded at 5-minute intervals for the first 15 minutes and at 15-minute intervals thereafter.
h) When primary power is returned to the building or facility, the time delay on retransfer to the primary power for the transfer switch with a minimum setting of 5 minutes shall be recorded.
i) The time delay on the prime mover cool down period and shutdown shall be recorded.

c. Phase loss test shall be performed to test the generator start circuit upon loss of any individual primary electrical phase serving the building. This may require a building power outage for the purpose of removing and then replacing individual primary fuses serving the building transformer. 600V main circuit breakers feeding the building loads should be opened for this test to prevent a single phase condition from occurring for the building motor loads. Starting of the generator during this test is optional provided the start circuits from the ATS(s) to the generator have already been previously tested and were found to be acceptable.

d. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions.

e. Check electrolyte level (if applicable) and specific gravity under both conditions. Test for contact integrity of all connectors.
f. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
g. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
h. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
i. A full tank of fuel shall be provided, replacing any fuel used for testing (N/A for natural gas).
j. Diesel fuel shall be treated with an alcohol-free additive to disperse water and clean injectors.
k. Copy of the generator's load test report shall be sent to the owner, and any state agency involved.
l. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Final Acceptance, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Final Acceptance.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

3.07 APPENDIX – GENERATOR LOAD ANALYSIS

A. The generator set minimum rated size shall be 350KW/438KVA, 0.8 PF, 3-phase, 480-volts, grounded-wye, 60 Hz.

B. The generator set described herein is based on a Natural Gas standby generator as manufactured by Caterpillar.

C. The Standby generator set shall be capable of starting and running the loads as listed herein.

	Transient Inrush		Running		Resultant Peak		Cumulative Running	
	Skva	Skw	kVA	kW	Skva	Skw	kVA	kW
Step-1	29.8	23.4	23.8	21.3	29.8	23.4	23.8	21.3
Step-2	175.3	97.0	121.2	96.7	199.1	119.1	121.2	96.7
Step-3	202.7	68.9	117.1	96.3	199.1	200.7	117.1	96.3

	Maximum Step		Maximum Peak		Final Running	
	Skva	Skw	Skva	Skw	kVA	kW
Summary	202.7	97.0	199.1	200.7	121.2	96.7

END OF SECTION

SECTION 26 32 14 - ENGINE GENERATORS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes packaged engine-generator sets for emergency power supply with the following features:
   1. Natural Gas engine.
   2. Unit-mounted cooling system.
   3. Unit-mounted control and monitoring.
   4. Performance requirements for sensitive loads.
   5. Outdoor enclosure.

B. Related Sections include the following:
   1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.02 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.03 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
   1. Thermal damage curve for generator.
   2. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
   2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators.
   3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
   4. Wiring Diagrams: Power, signal, and control wiring.
   5. Maintenance platform detailed construction.
   6. Circuit breakers installed at the generator.

C. Qualification Data: For installer, manufacturer, and testing agency.

D. Source quality-control test reports.
   1. Certified summary of prototype-unit test report.
   2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
   3. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   4. Report of sound generation.
   5. Report of exhaust emissions showing compliance with applicable regulations, including EPA requirements.
   6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For packaged engine generators include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.

B. Manufacturer Qualifications: The engine generator supplier shall maintain 24 hour parts and service capability within 100 miles of the project site. The distributor shall stock parts as needed to support the generator set package for this specific project. The distributor shall carry sufficient inventory to cover no less than 80% of the parts service within 24 hours and 95% within 48 hours.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASME B15.1.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

J. Comply with NFPA 111.

K. Comply with UL 2200.

L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

N. The emergency generator must be in compliance with all applicable requirements of 40 CFR Part 60 Subpart IIII.
1. The engine will be provided along with manufacturer certification of compliance with pertinent emission limits.

1.05 PROJECT CONDITIONS.

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
1. Ambient Temperature: 5 to 40 deg C.
2. Altitude: Sea level to 1000 feet.

1.06 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases.

1.07 WARRANTY

A. Special Warranty: Five Year Standby Generator Set Warranty
   1. The manufacturer's standard warranty shall in no event be for a period of less than Five (5) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall be limited to 500 hours annually for the system warranty by both the manufacturer and servicing distributor. Submittals received without written warranties as specified will be rejected in their entirety.
   2. Warranty shall include a temporary generator set in the event a warrantable repair will take more than 48 hours. Selling dealer must have a minimum of 100 units in its rental fleet to assure a temporary unit is available if needed. Provide documentation as such.

1.08 DOCUMENTATION AND TRAINING

A. Documentation: Prior to Final Acceptance, the manufacturer shall supply three (3) copies of the complete instruction manuals to Owner. The manuals shall include operation and maintenance procedures, complete parts lists, dimensional drawings, and unit wiring diagrams and schematics, and interconnection wiring diagrams.

B. Training: Prior to Final Acceptance, the manufacturer shall provide comprehensive training to the Owner’s designated personnel. Training shall cover, but not be limited to, operation, maintenance and troubleshooting of the equipment.

1.09 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Final Acceptance, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 MAINTENANCE MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
   2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
   3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Caterpillar; Engine Div.
   2. Generac Power Systems, Inc.
   3. Onan/Cummins Power Generation; Industrial Business Group.

2.02 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
   1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated herein, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Output Connections: Three-phase, four wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components.

D. Generator-Set Performance:
1. Steady-State Voltage
2. Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 15 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
4. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
7. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
9. Below requires 10-second maximum start time under specific conditions and includes startup only, not load assumption.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.
    a. This generator will be used to provide emergency standby power for egress lighting. The transfer switch and generator system shall provide rated voltage and frequency to the egress lighting system within 10-seconds from the time the normal power source to the transfer switch has been de-energized. For generators fueled by natural gas or propane, any required gas purge cycle shall be accounted for and included in this 10-second requirement.

2.03 ENGINE

A. Fuel: Natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:
1. Natural Gas System:
    a. Carburetor.
    b. Secondary gas regulator.
    c. Fuel shutoff solenoid valve.
    d. Flexible fuel connector.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Minimum coolant temperature shall not be less than 120 degrees F.

G. Governor: Adjustable isochronous, with speed sensing. Steady state operating band shall be within 2%. The generator controls shall accommodate harmonic distortion within the criteria of IEEE 519.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
   1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
   3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
   4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
   5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
      a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
      b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

I. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
   1. Configuration: Vertical air discharge.
   2. Radiator Core Tubes: Aluminum.
   3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
   4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
   5. Fan: Driven by multiple belts from engine shaft
   6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

J. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   1. Minimum sound attenuation specified below in sound attenuation.
   2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.
   3. The exhaust silencer outlet shall be terminated with a tailpipe (45 degree cut) or an exhaust elbow and ran cap and directed away from buildings and pedestrian pathways.

K. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

L. Starting System: 24-V electric, with negative ground.
   1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
   2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
   3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least two times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Automatic, solid-state, current limiting, float/equalizing battery charger. Unit shall comply with UL 1236 and include the following features:
    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent. Equipped with overload protection and voltage surge suppressors.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.04 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
    1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
    2. Current and Potential Transformers: Instrument accuracy class.

C. Indicating and Protective Devices and Controls as required by NFPA 110 for Level 1 system, and the following:
    1. AC voltmeter.
    2. AC ammeter.
    3. AC frequency meter.
    4. DC voltmeter (alternator battery charging).
    5. Engine-coolant temperature gage.

6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.
12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Generator overload.

D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

E. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.
6. Ground Fault Indication for circuit protective devices 150-volts or greater to ground and rated at 1,000-amps or more. Comply with NEC 700.7.

F. Remote Alarm Annunciator: An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

G. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
1. Provide two (2) remote Emergency-Stop Switches.
   a. Install at locations as shown on the plans.
2. Switches shall be weather proof type.

H. BAS interconnection: Provide a BACnetIP output to the building BAS system that will send an alarm to the central campus control system whenever the generator is running.

I. Fire Alarm interconnection: Provide a output to the building Fire Alarm system that will send a supervisory alarm to the fire alarm control panel whenever the generator is running.

2.05 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.

4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

B. Load Shed Control: Upon generator overload, generator shall signal the lowest priority automatic transfer switch to switch to the neutral position.
   1. Provide the necessary control panel and internal logic circuit boards to monitor the generator load and/or frequency.
   2. Provide the necessary connections to the Automatic Transfer Switch(es) to perform the load shed based upon the generator overload condition.
   3. Provide all necessary conduit and wiring for this control function.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.06 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Drip proof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
   1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Subtransient Reactance: 12 percent, maximum.

2.07 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or pre-engineered reach-in enclosure with the following features:
   1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
   2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
   3. Space Heater: Thermostatically controlled and sized to prevent condensation.
   4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
   5. Radiator Exhaust air shall be deflected 90-degrees upward using a screened hood.
   6. Hinged Doors: With padlocking provisions.
   7. Ventilation: Intake equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
   8. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
   9. Muffler Location: Within enclosure.

10. Sound attenuated to 85 dBA or less as measured 10-ft. from any exterior wall surface of the generator set enclosure.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at standby rating with ambient temperature at top of range specified in system service conditions.
   1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

D. Interior Lights with Switch: Factory-wired, vapor-proof-type fixtures within housing; arranged to illuminate controls and accessible interior. Connected from the factory to the supplied load center panel.
   1. Provide one (1) dedicated 120-volt lighting circuit from an interior panelboard and connect to the lighting fixture.
   2. AC lighting system and connection point for operation when remote source is available.
   3. DC lighting system for operation when remote source and generator are both unavailable.

E. Convenience Outlets: Provide a minimum of 1 GFCI receptacle, factory mounted.
   1. Provide one (1) dedicated 120-volt circuit from an interior panelboard and connect to the generator receptacle.

F. Sound attenuation:
   1. The entire enclosure except for the louvered openings shall have sound attenuation material mechanically attached to the interior surfaces of the unit.
   2. The sound absorption material shall be held in place by a perforated galvanized metal sheeting to form a removable section easily inspected by maintenance personnel.
   3. The sound attenuation material and fastening system shall apply to the enclosure roof as well as the side panels and doors.
   4. The enclosure package shall be designed to achieve an 86.5dBa sound rating when measured at a distance of 23 feet, free field.

G. Base and mounting:
   1. The generator set and enclosure shall be mounted and shipped to the jobsite on a common structural steel sub-base. Provisions for crane unloading of the complete package shall be designed into the base of the unit.
   2. The base and enclosure assembly shall allow room within the package to mount and maintain the specified battery charger, engine starting batteries, racks, and cables, generator mounted mainline circuit breaker(s), an engine/generator control panel, and other items as specified or as shown on the drawings.
   3. The entire unit consisting of generator set, base, enclosure, and all other specified items including all liquids (i.e., fuel oil, lube oil and cooling water) shall be calculated by the manufacturer. The base of the unit shall be engineered, designed, and manufactured as a heavy duty, welded steel construction with four (4) point lifting provisions as used on heavy duty construction installations.
   4. Details and manufacturer’s certification of the base construction shall be included with the drawings submitted for approval.

H. Enclosure flooring:
   1. The floor of the enclosure shall be designed and constructed in such a manner as to prevent the entrance of rodents. This may be accomplished with solid metal or expanded metal grating but, in any event, shall be capable of supporting any ancillary equipment specified which may be secured to it (such as batteries, day tanks, etc.) plus the anticipated weight of maintenance personnel and their tools.
   2. Under no circumstances shall the floor area or any of its parts be considered for cooling air intake or discharge requirements of the generator set or its associated equipment, nor shall its properties as a “heat sink” or heat dissipating medium be utilized in any manner whatsoever in this application.

2.08 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
   1. Material: Natural rubber.
   2. Durometer Rating: 30.
   3. Number of Layers: Four.

2.09 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
   1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
   1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
   2. Full load run.
   3. Maximum power.
   4. Voltage regulation.
   5. Transient and steady-state governing.
   6. Single-step load pickup.
   7. Safety shutdown.
   8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
   9. Report factory test results within 10 days of completion of test.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases.

D. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger. Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

E. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
   1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

F. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.
   1. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 23 Section "Facility Natural-Gas Piping."

F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 as specified here including, but not limited to:
      a. 100% load test of the generator. This test is designed to determine that the generator system will deliver full load output as connected at the site. Typically, this test is performed prior to the building load testing and before final terminations of the emergency system conductors. The test shall be as follows:
         1) Generator load Bank Test:
            a) The generator shall be subjected to a three-hour test using resistive load bank with a 1.0 power factor. This test shall be performed at the job site in the presence of the Engineer. The contractor shall provide the resistive load bank to test the generator.
            b) One hour at 50% load.
            c) One hour at 75% load.

d) One hour at 100% load.
e) Upon completion of the three-hour load test, the generator shall be shut-down after the cooling period. The generator shall be started and immediately upon reaching rated rpm, 100% load shall be applied to demonstrate one-step full load capability. The capability of the system to pick up full standby service load within 10 seconds of power outage shall be demonstrated.

2) The following shall be recorded every thirty minutes during the load bank testing:
a) Engine water temperature.
b) Oil pressure.
c) Voltage per phase and neutral.
d) Amperes per phases and neutral.
e) Frequency, KW, KVA, and power factor.
f) Room or outdoor ambient temperature.

b. Building load test. Prior to occupancy, provide a load bank and test the generator system per the requirements of NFPA-110. The test essentially determines that the generator system will automatically detect a power loss, automatically start, automatically switch the designated load to the generator in the specified time frame and power the building load for two hours. The load test utilizing the simulated building loads and the observation and recording of load changes and the resultant effect on the voltage and frequency shall be a minimum duration of 2 hours of generator run time. A total time of 3-hours shall be allotted for the testing period. The tests shall be as follows:
1) With the prime mover in a “cold start” condition and the emergency load at standard operating level, a primary power failure shall be initiated by opening the switch or breaker supplying the primary power to the building or facility. The test load shall be the load that the emergency generator serves.
2) Observe and record the following during building load testing of the generator:
a) If the facility is equipped with a fire pump, the pump shall be energized and running for the initial 5-minute period of the load test, then the pump can be de-energized while the testing is in progress.
b) The time delay starting of the generator.
c) The cranking time until the prime mover starts and run.
d) The time that the generator reach the operating speed.
e) The time that the generator achieved steady-condition after the transfer switches transferred to the emergency position.
f) The generator voltage, frequency, amperes, prime mover oil pressure, and water temperature.
g) The battery charge rate shall be recorded at 5-minute intervals for the first 15 minutes and at 15-minute intervals thereafter.
h) When primary power is returned to the building or facility, the time delay on retransfer to the primary power for the transfer switch with a minimum setting of 5 minutes shall be recorded.
i) The time delay on the prime mover cool down period and shutdown shall be recorded.

c. Phase loss test shall be performed to test the generator start circuit upon loss of any individual primary electrical phase serving the building. This may require a building power outage for the purpose of removing and then replacing individual primary fuses serving the building transformer. 600V main circuit breakers feeding the building loads should be opened for this test to prevent a single phase condition from occurring for the building motor loads. Starting of the generator during this test is optional provided the start circuits from the ATS(s) to the generator have already been previously tested and were found to be acceptable.

d. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions.

e. Check electrolyte level (if applicable) and specific gravity under both conditions. Test for contact integrity of all connectors.
f. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
g. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
h. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
i. A full tank of fuel shall be provided, replacing any fuel used for testing (N/A for natural gas).
j. Diesel fuel shall be treated with an alcohol-free additive to disperse water and clean injectors.
k. Copy of the generator's load test report shall be sent to the owner, and any state agency involved.
l. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Final Acceptance, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Final Acceptance.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

3.07 APPENDIX – GENERATOR LOAD ANALYSIS

A. The generator set minimum rated size shall be 350KW/438KVA, 0.8 PF, 3-phase, 480-volts, grounded-wye, 60 Hz.

B. The generator set described herein is based on a Natural Gas standby generator as manufactured by Caterpillar.

C. The Standby generator set shall be capable of starting and running the loads as listed herein.

	Transient Inrush		Running		Resultant Peak		Cumulative Running	
	Skva	Skw	kVA	kW	Skva	Skw	kVA	kW
Step-1	29.8	23.4	23.8	21.3	29.8	23.4	23.8	21.3
Step-2	266.1	143.4	102.4	81.1	288.6	165.4	126.1	102.4
Step-3	202.7	68.9	67.6	60.1	312.7	196.0	193.5	162.5

	Maximum Step		Maximum Peak		Final Running	
	Skva	Skw	Skva	Skw	kVA	kW
Summary	266.1	143.4	312.7	196.0	193.5	162.5

END OF SECTION

SECTION 26 33 53 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
      a. Surge suppression.
      b. Input harmonics reduction.
      c. Rectifier-charger.
      d. Inverter.
      e. Static bypass transfer switch.
      f. Battery and battery disconnect device.
      g. External maintenance bypass/isolation switch.
      h. Output isolation transformer.
      i. Remote UPS monitoring provisions.
      j. Battery monitoring.
      k. Remote monitoring.

B. ALTERNATES: Work of this section is affected by an alternate. Refer to Section 01 23 00 “Alternates”.

1.02 DEFINITIONS

A. EMI: Electromagnetic interference.

B. LCD: Liquid-crystal display.

C. LED: Light-emitting diode.

D. PC: Personal computer.

E. THD: Total harmonic distortion.

F. UPS: Uninterruptible power supply.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.

B. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
   2. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Manufacturer Certificates: For each product, from manufacturer.

C. Factory Test Reports: Comply with specified requirements.

D. Field quality-control reports.

E. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

F. Warranties: Sample of special warranties.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
   2. Cabinet Ventilation Filters: One complete set.

1.07 QUALITY ASSURANCE

A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. UL Compliance: Listed and labeled under UL 1778 by an NRTL.

E. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

1.08 WARRANTY

A. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
   1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

   2. Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	40 cycles
30 minutes	30 minutes	1.67	125 cycles
15 minutes	1.5 minutes	1.67	750 cycles

3. Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.75	40 cycles
1 hour	1 hour	1.75	80 cycles
15 minutes	45 seconds	1.67	2700 cycles

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.
   1. Special Warranty Period: Three years from date of Final Acceptance.

PART 2 PRODUCTS

2.01 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:
   1. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
   2. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
   3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
   4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
   5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
   6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
   7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
   8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
   9. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:
   1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
   2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual

selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.
1. Ambient Temperature for Electronic Components: 32 to 104 deg F.
2. Ambient Temperature for Battery: 41 to 95 deg F.
3. Relative Humidity: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 4000 feet.

2.02 PERFORMANCE REQUIREMENTS

A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:
1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.

B. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is five minutes.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 15 percent from nominal voltage.

D. Overall UPS Efficiency: Equal to or greater than 96 percent at 100 percent load, 90 percent at 75 percent load.

E. Maximum Energizing Inrush Current: Six times the full-load current.

F. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

G. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

H. Limitation of harmonic distortion of input current to the UPS shall be as follows:
1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
2. Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.

I. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

J. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

K. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.

L. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:
   1. 50 Percent: Plus or minus 5 percent.
   2. 100 Percent: Plus or minus 5 percent.
   3. Loss of AC Input Power: Plus or minus 1 percent.
   4. Restoration of AC Input Power: Plus or minus 1 percent.

M. Input Power Factor: A minimum of 0.8 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.

N. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

2.03 UPS SYSTEMS

A. Subject to compliance with requirements, provide by one of the following:
   1. Liebert Corporation; a division of Emerson.
   2. Eaton PowerWare.
   3. APC; a division of Schneider Electric.

B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, maintenance bypass switch and system controls.

C. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

D. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

E. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.
   1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B.
   2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

F. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

G. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

H. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

I. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.04 RECTIFIER-CHARGER

A. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
   1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.05 INVERTER

A. Description: Pulse-width modulated, with sinusoidal output.

B. Description: Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.06 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

2.07 BATTERY

A. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
   1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

B. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.
   1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

C. Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers mounted on acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.

D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. C&D Technologies, Inc.; Standby Power Division.
   2. Eaton Corporation; Powerware Division.
   3. EnerSys.
   4. Panasonic Corporation of North America; Panasonic Industrial Company.

2.08 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LED Touchscreen.
   1. Quantitative indications shall include the following:
      a. Input voltage, each phase, line to line.
      b. Input current, each phase, line to line.

c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.
e. System output voltage, each phase, line to line.
f. System output current, each phase.
g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:
   a. Normal operation.
   b. Load-on bypass.
   c. Load-on battery.
   d. Inverter off.
   e. Alarm condition.
3. Alarm indications shall include the following:
   a. Bypass ac input overvoltage or undervoltage.
   b. Bypass ac input overfrequency or underfrequency.
   c. Bypass ac input and inverter out of synchronization.
   d. Bypass ac input wrong-phase rotation.
   e. Bypass ac input single-phase condition.
   f. Bypass ac input filter fuse blown.
   g. Internal frequency standard in use.
   h. Battery system alarm.
   i. Control power failure.
   j. Fan failure.
   k. UPS overload.
   l. Battery-charging control faulty.
   m. Input overvoltage or undervoltage.
   n. Input transformer overtemperature.
   o. Input circuit breaker tripped.
   p. Input wrong-phase rotation.
   q. Input single-phase condition.
   r. Approaching end of battery operation.
   s. Battery undervoltage shutdown.
   t. Maximum battery voltage.
   u. Inverter fuse blown.
   v. Inverter transformer overtemperature.
   w. Inverter overtemperature.
   x. Static bypass transfer switch overtemperature.
   y. Inverter power supply fault.
   z. Inverter transistors out of saturation.
   aa. Identification of faulty inverter section/leg.
   bb. Inverter output overvoltage or undervoltage.
   cc. UPS overload shutdown.
   dd. Inverter current sensor fault.
   ee. Inverter output contactor open.
   ff. Inverter current limit.
4. Controls shall include the following:
   a. Inverter on-off.
   b. UPS start.
   c. Battery test.
   d. Alarm silence/reset.
   e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:
   1. UPS on battery.

2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.09 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full UPS load current.

D. Mounting Provisions: Separate wall- or floor-mounted unit.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

2.10 MONITORING BY REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.11 MONITORING BY REMOTE COMPUTER

A. Description: Communication module in unit control panel shall provide capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
1. Connectors and network interface units or modems for data transmission via BAS interconnection. Provide a gateway for remote monitoring/alarming.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.

2.12 BASIC BATTERY MONITORING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Albercorp.
2. BTECH, Inc.
3. Eaton Corporation; Powerware Division.
4. Liebert.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

C. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

D. Annunciation of Alarms: At UPS control panel.

2.13 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:
1. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
2. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
4. Alarm Contacts: Arranged to initiate local alarm for abnormal battery voltage or temperature.
5. Memory: Stores recorded data in nonvolatile electronic memory.
6. RS-232 Port: Permits downloading of data to a portable PC.
7. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

2.14 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation. Include the following:
1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.

C. Report test results. Include the following data:
1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete.
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

3.03 GROUNDING

A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.

3.04 IDENTIFICATION

A. Identify components and wiring according to Section 26 05 53 "Identification for Electrical Systems."
1. Identify each battery cell individually.

3.05 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.06 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:
1. Comply with manufacturer's written instructions.
2. Inspect interiors of enclosures, including the following:
a. Integrity of mechanical and electrical connections.
b. Component type and labeling verification.
c. Ratings of installed components.
3. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
4. Test manual and automatic operational features and system protective and alarm functions.
5. Test communication of status and alarms to remote monitoring equipment.
6. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
a. Simulate malfunctions to verify protective device operation.
b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
c. Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
d. Test output voltage under specified transient-load conditions.
e. Test efficiency at 50, 75, and 100 percent of rated loads.
f. Test remote status and alarm panel functions.
g. Test battery-monitoring system functions.

E. The UPS system will be considered defective if it does not pass tests and inspections.

F. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

G. Prepare test and inspection reports.

3.07 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated.

B. Monitoring and Testing Schedule: Perform monitoring and testing in four 10-day periods, each in a different season of the year.
   1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
   2. Schedule monitoring and testing after Final Acceptance, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:
   1. Current: Each phase and neutral and grounding conductors.
   2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
   3. Frequency transients.
   4. Voltage swells and sags.
   5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
   6. High-frequency noise.
   7. Radio-frequency interference.
   8. THD of the above currents and voltages.
   9. Harmonic content of currents and voltages above.

D. Monitoring and Testing Procedures for Each Test Period:
   1. Exploratory Period: For the first two days of the first scheduled monitoring and testing period, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
   2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.
      a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
      b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
      c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
      d. Using loads and devices available as part of the facility's installed systems and equipment create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.

e. Using temporarily connected resistive/inductive load banks, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.
1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:
1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in each report:
1. Description of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendation for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION

SECTION 26 36 00 - TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:
   1. Automatic transfer switches.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
   1. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch.
   2. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer-installed and field-installed wiring. Show both power and control wiring.

C. Qualification Data: For manufacturer and testing agency.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product include the following:
   1. Features and operating sequences, both automatic and manual.
   2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches, remote annunciator and control panels through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70..

G. Comply with NFPA 110.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.04 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Architect no fewer than seven days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's written permission.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Basis of Design: ASCO 4000 Series
      a. Approved Equal:
         1) ASCO.
         2) Eaton.
         3) Caterpillar; Engine Div.
         4) Emerson; ASCO Power Technologies, LP.
         5) Generac Power Systems, Inc.
         6) Kohler Power Systems; Generator Division.
         7) Onan/Cummins Power Generation; Industrial Business Group.
         8) Russelectric, Inc.

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
   1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
   2. Switch Action: Double throw; mechanically held in both directions.
   3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

K. Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device. In addition, devices shall communicate with BAS via BACnet IP.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
   1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
   2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
   3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

N. All feeders lugs, relays, timers, control wiring and accessories shall be front accessible.

O. All transfer switch coils, springs, and control elements shall be easily inspectable and conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.

P. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

Q. Multifunction Digital-Metering Monitor: Microprocessor-based unit equal to Square D PM650 suitable for three-or four-wire systems and with the following features:
   1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
      a. Phase Current: A, B, C, N
      b. Volts, Line to Line: A-C, C-B, C-A
      c. Volts, Line to Neutral: A-N, B-N, C-N
      d. Real Power (kW): A, B, C, Total
      e. Reactive Power (kVar): A, B, C, Total
      f. Apparent Power (kVA): A, B, C, Total
      g. Power Factor (True): A, B, C, Toal
      h. Frequency
      i. Real Energy (kWh): Three Phase Total
      j. Reactive Energy (kVARh): Three Phase Total
      k. Apparent Energy (KVah): Three Phase Total
      l. Energy Accumulation Modes: Signed, Absolute, Energy In, Energy Out
      m. KYZ Output
      n. Communications
      o. Front Display
      p. THD, Voltage & Current: A, B, C
      q. Current Demand: A, B, C, Present & Past
      r. Power Demand (kWd, kVARd, kVAd): Three Phase Total, Present & Past
      s. Date/Time Sampling: Peak Demands, Power Up/Restart, Resets
      t. Predicted Power Demand: kW, kVAR, kVA
      u. Advance Demand Options: Synch to Communications, Sliding Block Calculation
      v. Onboard alarms: Over/Under Conditions. Phase Unbalance Conditions
      w. Min/Max Readings: Frequency, Current, Voltage, Power, Power Factor, THD
      x. Data and Event Logs
      y. Downloadable Firmware

z. Revenue Accuracy, ANSI: C12.16
aa. Accuracy (of reading): Power/Energy – 5%, Current/Voltage – 2.5%
bb. Harmonic Response (Based on Sample Rate): 31
cc. UL Listed

2. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.

2.03 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Remote Control Circuit:
1. Load shedding circuit initiated by removal of generator control voltage. Allows load shedding by priority.
2. Load shed contacts: A set of contacts to disconnect the ATS load from the emergency source when an overload condition occurs.
a. The load shed shall be initiated by the generator controls.
b. Load shed shall be programmable through the ATS or paralleling gear display window.
c. Criteria for the load shed control shall be as follows:
1) Trip point Function Trigger Condition- Active. Trip above threshold.
2) Trip Point Function Percentage Threshold- 95% of rated KW.
3) Trip Point Function Hysteresis Percentage- 5%.
4) Trip Point Function Trip Active Delay Time- 3 seconds.
d. The contractor shall provide all necessary conduit and wiring for the complete installation of this function.

F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

G. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.
a. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

H. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

I. Transfer Switch Control System:
1. The control module shall direct the operation of the transfer switch. The module's sensing and logic shall be microprocessor-based. The control settings shall be stored in non-volatile memory.
2. The control module shall have a three-position, key-operated, programming control switch. The key shall be removable in any position. The positions shall be:
a. Off – Allows all enabled accessories to be monitored only. Settings cannot be changed while in this position.
b. Local – Allows all enabled accessory settings to be changed locally at the transfer switch control panel.

c. Remote – Allows all enabled accessories to be altered via the remote communications port.

J. Automatic Transfer-Switch Features:
1. Under-voltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 70 to 95 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 5 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
   b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.
14. Anti single phasing protection shall detect regenerative voltage as failed source condition. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes; factory set for 5 minutes. Provides automatic defeat of delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored. If emergency power source should fail during the time delay period, the time delay shall be by passed and the switch shall return, immediately, to the normal source.
15. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source.

a. Interval is adjustable from 1 to 30 seconds, set from the factory at 1 second.
b. Connect to each elevator connected the transfer switch(es) circuit.
1) Provide 2#12, 1#12G, ¾"C for each elevator and connect to the elevator controller.

16. Auxiliary Contacts: Two sets of open/normally, Form C, dry contacts for each switch position, rated 10 A at 240-V ac for elevator pre-transfer signal.
a. Connect to each elevator connected to the transfer switch(es) for elevator car "On Emergency Power" indication light.
1) Provide 4#10, 1#12G, ¾"C from the transfer switch to each elevator connected to the transfer switch power circuit and connect to the elevator controller.

17. Auxiliary Contacts: Two sets of normally closed dry contacts that open whenever the transfer switch is in the Standby/Emergency position, rated 10 A at 240-V ac for elevator indication that standby power is available.
a. Connect to each elevator connected to the transfer switch(es) for elevator car "On Emergency Power" indication light.
1) Provide 4#10, 1#12G, ¾"C from the transfer switch to each elevator connected to the transfer switch power circuit and connect to the elevator controller.

2.04 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Switch position.
3. Switch in test mode.
4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.05 REMOTE ANNUNCIATOR AND CONTROL SYSTEM

A. Functional Description: Include the following functions for indicated transfer switches:
1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Indication of switch position.
3. Indication of switch in test mode.
4. Indication of failure of digital communication link.
5. Key-switch or user-code access to control functions of panel.
6. Control of switch-test initiation.
7. Control of switch operation in either direction.
8. Control of time-delay bypass for transfer to normal source.

B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

C. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
1. Controls and indicating lights grouped together for each transfer switch.
2. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
3. Digital Communication Capability: Matched to that of transfer switches supervised.

4. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

D. BAS interconnection: Provide a BACnet output to the building BAS system that will allow status monitoring by the central campus control system.

2.06 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 EXECUTION

3.01 APPLICATION

A. Four-Pole Switches: Where four-pole switches are indicated, install neutral switching.

3.02 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

B. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

C. Identify components according to Division 26 Section "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. When load shed circuits are specified the Automatic Transfer Switches shall be arranged to be switched to the neutral (no load) position unless otherwise shown on the drawings:
   1. Legally Required Standby Systems as defined by the National Electrical Code shall be the highest priority and shall be first to be connected to the emergency power source. This transfer switch shall not be load shed.
   2. Optional Standby Systems as defined by the National Electrical Code shall be the lowest priority and shall be the last load to be connected to the emergency power source and the first to be load shed during a generator overload condition.

3.03 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.

2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.
5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
    a. Verify grounding connections and locations and ratings of sensors.
    b. Assist in verifying grounding connections and locations and ratings of sensors.
    c. Assist in observing reaction of circuit-interrupting devices when simulated fault current is applied at sensors.

D. Testing Agency's Tests and Inspections:
1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.
4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
   a. Verify grounding connections and locations and ratings of sensors.

E. Coordinate tests with tests of generator and run them concurrently.

F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

G. Remove and replace malfunctioning units and retest as specified above.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.

B. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 26 36 10 – GENERATOR DOCKING STATION

PART 1 GENERAL

1.01 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ETL/UL LISTED to 1008 Standards

C. UL 50 LISTED

1.02 COORDINATION

A. Coordinate layout and installation of Generator Docking Station, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.03 GUARANTEE/WARRANTY

A. Manufacturer Warranty shall be provided for a minimum of 1 Year, after Final Acceptance.

B. The equipment installed under this contract shall be left in proper working order.

C. New materials and equipment shall be guaranteed against defects in composition, design or workmanship. Guarantee certificates shall be furnished.

PART 2 PRODUCTS

2.01 DOCKING STATION

A. Manufacturers: Subject to compliance with requirements, provide products by on of the following:
   1. Bases of Design: TRYSTAR Model No.: GDS-06W-LM-ABDGM
   2. PSI Power & Controls.
   3. Powertron.

2.02 GENERAL REQUIREMENTS

A. Enclosure
   1. NEMA 3R Rain-Tight Aluminum Enclosure
      a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of temporary cabling that prevents unauthorized tampering while in use.
      b. NEMA 3R Integrity shall be maintained while temporary cabling is connected during use.
      c. Front and Side shall be accessible for maintenance.
      d. Top, Side, and Bottom shall be accessible for permanent cabling.
   2. Powder coat
      a. Paint after fabrication shall be Hammer tone Gray.

B. Phase, Neutral, and Ground Busbar
   1. Material: Silver-plated Copper
   2. Equipment Ground Bus: bonded to box.
   3. Isolated Ground Bus: insulated from box.
   4. Ground Bus: 100% of phase size.
   5. Neutral Bus: Neutral bus rated 100 percent of phase bus.

C. Temporary generator connectors shall be Camlok style mounted on gland plate.
   1. Camlok shall be 16 Series model and color coded according to system voltage requirements.
   2. Camlok connections shall be Bus Bar Style, Cabling or Double Set Screw is not acceptable.
   3. Camlok connection shall be protected against accidental contact while not in use.

D. Permanent Connection shall be factory installed broad range set-screw mechanical type, located behind a physical barrier.

E. Short Circuit & Withstand Rating
   1. Shall be minimum 65 KAIC unless otherwise indicated on drawings.

F. Voltage & Amperage
   1. 480Y/277V, 3 Phase, 600A.

G. Factory Installed Phase Rotation Monitor Device:
   1. Phase monitoring relay to be factory installed.

H. Additional accessories shall be included in submittal drawing as follows:
   1. A: Two Wire Auto Start
   2. B: Battery Charger Receptacle 20A duplex, GFCI, 125V
   3. D: Block Heater Receptacle 30A, L5-30, 125V
   4. M: Listed Monitoring Device

PART 3 PART 3 EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive Generator Docking Station for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Surface, Flush or Base Mounted: Determined by Application
   1. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.

3.03 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

C. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.04 FIELD QUALITY CONTROL

A. Third Party Tests and Inspections to include the following:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

B. Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes scanning results. Include notation.

END OF SECTION

SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes lightning protection system for ordinary structures.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
   2. Include raceway locations needed for the installation of conductors.
   3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
   4. Include roof attachment details, coordinated with roof installation.
   5. Calculations required by NFPA 780 for bonding of metal bodies.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Lightning protection cabling attachments to roofing systems and accessories.
   2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
   3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.
   1. Include the following:
      a. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:
   1. UL Master Label Certificate.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: LPI Master Installer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Advanced Lightning Technology, Ltd.
   2. East Coast Lightning Equipment Inc.
   3. ERICO; nVent.
   4. Harger Lightning & Grounding.
   5. Heary Bros. Lightning Protection Co. Inc.

6. Independent Protection Co.
7. National Lightning Protection.
8. Preferred Lightning Protection.
9. Robbins Lightning, Inc.
10. Thompson Lightning Protection, Inc.

2.02 PERFORMANCE REQUIREMENTS

A. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.

B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.03 MATERIALS

A. Air Terminals:
1. Copper unless otherwise indicated.
2. 3/8-inch diameter by 24 inches long.
3. Rounded tip.
4. Integral base support.

B. Air Terminal Bracing:
1. Copper.
2. 1/4-inch diameter rod.

C. Class 1 Main Conductors:
1. Stranded Copper: 57,400 circular mils in diameter.

D. Secondary Conductors:
1. Stranded Copper: 26,240 circular mils in diameter.

E. Ground Loop Conductor: Stranded copper.

F. Ground Rods:
1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Rods shall be not less than 120 inches long.

G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install lightning protection components and systems according to UL 96A.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed installations in UL 96A.
1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.02 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.03 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.04 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Perform inspections as required to obtain a UL Master Label for system.
   2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

END OF SECTION

SECTION 26 41 14 - LIGHTNING PROTECTION SYSTEM SECUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Securement of lightning protection system to conventional roofing membrane.

1.02 REFERENCES

A. NFPA 70-2020 - National Electrical Code; 2020.

B. NFPA 780 - Standard for the Installation of Lightning Protection Systems; 2023.

1.03 QUALITY ASSURANCE

A. Conform to NFPA 780.

B. Conform to NFPA 70-2017.

PART 2 PRODUCTS

2.01 MATERIALS

A. Roofing membrane: Specified in Section 07 50 00.

PART 3 EXECUTION

3.01 SECUREMENT TO ROOFING

A. General: Where exposed conductors course across roofing, secure conductors to masonry units, not to roofing membrane.
   1. Layout conductor runs neatly, in an orthogonal pattern, and to avoid maintenance traffic, drains, and other penetrations.
   2. Provide additional layer of "sacrificial" roofing membrane under conductor and all attachments.
   3. To secure air terminals, adhere air terminal bases to layer of “sacrificial” roofing membrane. Do not adhere to roof membrane surface.
   4. To secure conductors, adhere conductor clamps to layer of “sacrificial” roofing membrane. Do not fasten to roof membrane surface.

END OF SECTION

SECTION 26 51 00 - INTERIOR LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Interior lighting fixtures and LED drivers.
   2. Exit signs.
   3. Lighting fixture supports.

1.02 DEFINITIONS

A. CRI: Color-rendering index.

B. CU: Coefficient of utilization.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Luminaire: Complete lighting fixture, including driver housing if provided.

F. RCR: Room cavity ratio.

1.03 SUBMITTALS

A. Product Data: Partial submittals are not acceptable. Submittals that are incomplete shall be cause for rejection for the entire submittal. For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of lighting fixture including dimensions.
   2. Lamp data shall include the following:
      a. Average rated life @ 3 hours per start.
      b. Color temperature in Kelvin.
      c. Color Rendering Index.
      d. Approximate Lumens initial @25^{0}C.
      e. Nominal Wattage.
      f. Operating ambient temperature range.
   3. Energy-efficiency data.
   4. Life, output, and energy-efficiency data for lamps.
   5. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
      a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
   1. Wiring Diagrams: Power and control wiring.

C. Qualification Data: For agencies providing photometric data for lighting fixtures.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals per 2018 North Carolina Energy Conservation Code Section C408.3.2 Lighting System Operation Manual Prescriptive Criterion. Include the following:
   1. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.
   2. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended re-lamping shall be clearly identified.
   3. A schedule for inspecting and recalibrating all lighting controls.

4. A narrative of how each system is intended to operate, including recommended set points.

F. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

E. Provide luminaires for a single manufacturer for each luminaire type.

F. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.05 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.06 MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. LED Fixtures: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Plastic Diffusers and lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Battery and Charger Data: One for each emergency lighting unit.
   4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

1.07 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 5 years from date of Final Acceptance.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. On the Lighting Fixture Schedule located on the drawings or where titles within this specification section that introduce lists, the following requirements apply to product selection:
   1. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified on the Lighting Fixture Schedule or as listed herein for lamps, ballasts, and drivers.

2.02 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. A UL listing shall be provided for each fixture type, and the appropriate label or labels shall be affixed to each fixture in a position concealing it from normal view. UL labels shall not be installed on reflectors. Fixtures shall be listed according to their exposure in respective environments, e.g. wet location, damp location, shower light, etc.

B. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

C. LED Fixtures: Comply with IESNA LM-79 and LM-80.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.
   4. Laminated Silver Metallized Film: 90 percent.

H. Plastic Diffusers, Covers, and Globes:
   1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
      b. UV stabilized.
   2. Glass: Annealed crystal glass, unless otherwise indicated.

2.03 LIGHTING FIXTURES

A. See lighting fixture schedule drawing for lighting fixture specifications.

B. Miscellaneous
   1. All fixtures shall be completely wired at the factory.
   2. Each recessed and semi-recessed fixture shall be finished with a mounting frame or ring compatible with the ceiling in which they are to be installed. The frames and rings shall be one (1) piece or constructed with electrically welded butt joints, and of sufficient size and strength to sustain the weight of the fixture.
   3. Make certain that all recessed fixtures have trims and mounting components compatible with the ceiling in which they are to be installed. Shop drawings shall clearly indicate the compatibility of the fixture to the ceiling.
   4. The contractor shall use factory accessories for mounting and supporting the lighting fixtures in the ceilings.
      a. Conduit sections installed and wired horizontally across ceiling grids and used for supporting lighting fixtures will not be accepted.
   5. All sheet metal work shall be free from tool marks and dents, and shall have accurate angles bent as sharp as compatible with the gauges of the required metal. All intersections and joints shall be formed true of adequate strength and structural rigidity to prevent any distortion after assembly. All sheet metal shall be void of light leaks. All edges shall be finished so there are no sharp edges exposed. All miters shall be in accurate alignment with abutting intersection members. Piecing of plates in individual runs on single plans, and the use of spliced pieces of filler materials to cover defective workmanship, will not be tolerated. Sheet metal work shall be properly fabricated in order that planes will not deform, that is , become concave or convex, due to normal expected ambient and operating conditions.

2.04 LED DRIVER

A. LED dimming shall be equal in range and quality to a commercial grade incandescent dimmer. Quality of dimming to be defined by dimming range, freedom from perceived flicker or visible stroboscopic flicker, smooth and continuous change in level (no visible steps in transitions), natural square law response to control input, and stable when input voltage conditions fluctuate over what is typically experience in a commercial environment. Demonstration of this compliance to dimming performance will be necessary for substitutions or prior approval.

B. Ten-year expected life while operating at maximum case temperature and 90 percent non-condensing relative humidity.

C. Driver must limit inrush current.
   1. Base specification: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 $Amps^2$ – seconds.
   2. Preferred Specification: Meet or exceed 30mA^2s at 277VAC for up to 50 watts of load and 75A at 240us at 277VAC for 100 watts of load.

D. Withstand up to a 1,000-volt surge without impairment of performance as defined by ANSI C62.41 Category A.

E. No visible change in light output with a variation of plus/minus 10 percent line voltage input.

F. Total Harmonic Distortion less than 20% percent and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.

G. Driver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance:
   1. Adjustment of forward LED voltage, supporting 3V through 55V.
   2. Adjustment of LED current from 200mA to 1.05A at the 100 percent control input point in increments of 1mA.
   3. Adjustment for operating hours to maintain constant lumens (within 5 percent) over the 50,000 hour design life of the system, and deliver up to 20 percent energy savings early in the life cycle.

H. Driver should be UL Recognized under the component program and shall be modular for simple field replacement. Drivers that are not UL Recognized or not suited for field replacement will not be considered.

I. Drivers to track evenly across multiple fixtures at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.

J. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers
   1. Must meet IEC 60929 Annex E for General White Lighting LED drivers.
   2. Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 mA per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
   3. Must meet ESTA E1.3 for RGBW LED drivers.

K. LED drivers shall be UL 1310 and UL 879A Class 2 compliant. Drivers shall be electronic low-voltage, dimming protocol as indicated on drawings and in coordination with control system, unless noted otherwise. Drivers shall use convection cooling and shall have an operating temperature range of -40 to 55 degrees C. Drivers shall be listed for the environment in which they are located.

L. Driver mean time between failures shall be greater than 100,000 hours at full load and 25 degrees C ambient. EMC shall compliant to 47CFR, Part2, Part15 and Cispr PUB, 22 Class B. Acoustic noise shall be less than 24dB (20-20k Hz). Power factor shall be greater than 0.97 at full load. Leakage current shall not exceed 300 uA.

M. Drivers shall have over-voltage, over-current and short-circuit protection with auto recovery.

2.05 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction and with fixture specified.
   1. Emergency Exit Sign: It shall be completely self-contained, provided with maintenance-free battery, automatic charger, and other features and a minimum of 90 minutes operating endurance. Must have a normal life expectancy of 10 years.
   2. Fixture must be third-party listed as emergency lighting equipment, and meet or exceed the following standards: NEC, N.C. Building Code, North Carolina Energy Code, NFPA-101, and NEMA Standards.

3. LED: The use of LED is required due to their reliable performance, low power consumption, and limited maintenance requirements.
4. Maximum LED failure rate shall be 25% within a seven (7) year period; otherwise, if exceeded, manufacturer shall replace the complete unit at no charge to the owner.

B. Internally Lighted Signs:
1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
a. Battery: It shall be sealed, maintenance free type, with minimum of 90 minutes operating endurance. Must have a normal life expectancy of 10 years. Batteries shall be a high temperature type with an operating range of 0 degree C to 60 degrees C and contain a resealable pressure vent, and provided with + positive terminal and – negative terminal.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.
h. Unit Test: Contractor shall perform a test on each unit after it is permanently installed and charged for a minimum of 24 hours. Battery shall be tested for 90 minutes. The battery test shall be done 10 days prior to final inspection. Any unit which fails the test must be repaired or replaced, and tested again. Copy of the test report shall be sent to the State Construction Office.
3. Master/Remote Sign Configurations:
a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.06 LED LAMPS

A. LED lamps shall comply with ANSI C78.377, 2008 using a 4-step Macadam ellipse of the 4000K points on the Planckian Locus (color binning). Color-rendering index, CRI shall be greater than 90. Lamps shall have an R9 value greater than 50, measured under the same conditions as the CRI. LED lamps shall be dimmable without flicker from 5-100%. Power factor shall be greater than 0.9. Lamp life shall be greater than 25,000 hours and lumen maintenance shall greater than 80% on initial output at 40% of rated life.

2.07 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

H. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.08 REQUIREMENTS FOR INDIVIDUAL LIGHTING FIXTURES

A. See Lighting Fixture Schedule:

PART 3 EXECUTION

3.01 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture. Lamp and socket orientations for similar fixtures shall be identical within each individual space.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
   1. Where a lighting fixture replaces a section or a part of a ceiling tile, the fixture is to be supported:
      a. At the two (2) opposite ends to the steel frame of the building with the same type of wire as used to support the lay-in ceiling track. Attach one end of the wire to one corner of the luminaire and the other end to the building's structural system.
      b. The lay-in luminaire shall then be screwed to the main runners of the lay-in ceiling track at all four (4) corners using sheet metal screws.
   2. Light leaks between ceiling trims of recessed lighting equipment and the ceiling will not be tolerated. Locate not more than 6 inches from fixture corners.
   3. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   4. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees with listed clips installed per manufacturer's instructions.
   5. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging. Pendant rods shall be all-thread, minimum of 3/8" diameter Galvanized carbon steel.
   2. Stem-Mounted, Single-Unit Fixtures:
      a. Common and office areas with non-industrial type fixtures:
         1) Suspend with single pendant or aircraft cable as indicated on the drawings.
         2) Provide swivel plate/connection at top of stem for stem hangers.
      b. Mechanical, Electrical Storage, Misc. rooms with industrial type fixtures:
         1) Suspend with twin-stem hangers or provide steel strut attached along the length of the fixture and a single stem attached to the strut.
         2) Provide swivel plate/connection at top of stem for stem hangers.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

4. The Contractor shall furnish and install all necessary channels, support wires or rods, etc. to provide a structurally sound system.

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

E. Yokes, brackets and supplementary supporting members needed to mount lighting fixtures to two (2) inch carrier channels or other suitable ceiling members shall be furnished and installed by the Contractor.

F. Upon completion of the installation, all lighting fixtures shall be cleaned to the satisfaction of the Engineer.

G. Reflectors, reflector cones and visible trim of all lighting fixtures shall not be installed until completion of plastering, ceiling tile work, painting and general cleanup. They shall be carefully handled to avoid scratching or fingerprinting and shall be, at the time of acceptance by the Owner, completely clean. All Alzak parabolic cones shall be guaranteed against discoloration for a minimum of two (2) years, and, in the event of premature discoloration, shall be replaced by the manufacturer, including both materials and the cost of labor.

3.02 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Connect all battery-ballast ahead of local area lighting switch to provide emergency operation whenever the power to the local area circuit is de-energized.

3.03 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Verify normal operation of each fixture after installation.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

D. Corroded Fixtures: During warranty period, replace fixtures that show any signs of corrosion.

E. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.
1. Verify normal transfer to battery power source and retransfer to normal.
2. Unit Test: Contractor shall perform a test on each unit after it is permanently installed and charged for a minimum of 24 hours. Battery shall be tested for 90 minutes with results documented on the form at the end of this section. The battery test shall be done 10 days prior to final inspection. Any unit which fails the test must be repaired or replaced, and tested again. Copy of the test report shall be sent to the Engineer.
3. Complete Emergency-Lighting Battery Unit testing form provided herein.

F. Provide adjustments to lighting fixtures that are designed to be modified in the field for light intensity aiming purposes.
1. This shall be directed in the field by the engineer. The contractor shall notify the engineer in writing fourteen (14) days in advance to arrange a date and time for the adjustments.
2. Lighting fixtures installed exterior to the building and/or in interior areas with exterior glass shall be adjusted after sunset.

EMERGENCY-LIGHTING BATTERY UNIT

VOLTAGE DROP TEST FORM

DATE OF TEST: _____

LOCATION: _____

CLIENT: _____

TEST PERFORMED BY _____

TEST #	BATTERY UNIT LOCATION	STARTING DC VOLTAGE AT BATTERY	ENDING VOLTAGE AFTER 90 MIN. w/o AC POWER	% VOLTAGE DROP (12.5% MAX.)

ENGINEER'S SIGNATURE: _____

TESTER'S SIGNATURE: _____

CONTRACTOR'S LICENSE #: _____

END OF SECTION

SECTION 26 52 13 - EMERGENCY AND EXIT LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Emergency lighting.
   2. Exit signs.
   3. Materials.
   4. Luminaire support components.

1.02 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
   1. Include data on features, accessories, and finishes.
   2. Include physical description of the unit and dimensions.
   3. Battery and charger for light units.
   4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
   5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
      a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Product Schedule:
   1. For emergency lighting units. Use same designations indicated on Drawings.
   2. For exit signs. Use same designations indicated on Drawings.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Luminaires.
   2. Suspended ceiling components.
   3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
   4. Structural members to which equipment will be attached.
   5. Size and location of initial access modules for acoustical tile.
   6. Items penetrating finished ceiling including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Ceiling-mounted projectors.
e. Sprinklers.
f. Access panels.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Provide seismic qualification certificate for each piece of equipment.

E. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample Warranty: For manufacturer's warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.07 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products and complying with applicable IES testing standards.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.09 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Two year(s) from date of Final Acceptance.

B. Retain article for rechargeable batteries for emergency lighting equipment. Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Final Acceptance. Full warranty shall apply for the entire warranty period.
2. Warranty Period for Self-Powered Exit Sign Batteries: Five years from date of Final Acceptance. Full warranty shall apply for the entire warranty period.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.02 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.
   1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
   2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
      b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
      c. Humidity: More than 95 percent (condensing).
      d. Altitude: Exceeding 3300 feet.
   4. Nightlight Connection: Operate continuously at 40 percent of rated light output.
   5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
      a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
      b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   6. Battery: Sealed, maintenance-free, nickel-cadmium type.
   7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
   8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit

triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.03 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
   1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
      a. Amerlux.
      b. Cooper Lighting Solutions; Signify North America Corp.
      c. Evenlite, Inc.
      d. Hubbell Incorporated, Lighting.
      e. Lithonia Lighting; Acuity Brands Lighting, Inc.
      f. Ruud Lighting Direct.
      g. Signify North America Corporation (formerly Philips Lighting).
   2. Operating at nominal voltage of 277 V ac.
   3. Lamps for AC Operation:
      a. LEDs; 50,000 hours minimum rated lamp life.
   4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

2.04 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:
   1. Smooth operating, free of light leakage under operating conditions.
   2. Designed to permit relamping without use of tools.
   3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

2.05 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.06 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position when testing emergency power unit.
   3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls.
   2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
   3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
   4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
   3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.05 STARTUP SERVICE

A. Perform startup service:
   1. Charge batteries minimum of one hour and depress switch to conduct short-duration test.
   2. Charge batteries minimum of 24 hours and conduct one-hour discharge test.

3.06 ADJUSTING

A. Adjustments: Within 12 months of date of Final Acceptance, provide on-site visit to do the following:
   1. Inspect all luminaires. Replace batteries, signs or luminaires that are defective.
      a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
   2. Conduct short-duration tests on all emergency lighting.

END OF SECTION

SECTION 27 05 00 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Communications equipment coordination and installation.
   2. Common communications installation requirements.

1.02 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.03 COORDINATION

A. Coordinate arrangement, mounting, and support of communications equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Panels."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.01 PRE-INSTALLATION MEETING

A. The Contractor shall attend a meeting with ITS prior to commencing installation activities. This meeting will be held at WTCC at a location determined by ITS and may include a site visit. The purpose of the meeting is to review project specifics and requirements.

3.02 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.03 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section " Firestopping."

3.04 ACCESS FOR SERVICE

A. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Coordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm’s length.

3.05 GUARANTEE

A. All wiring, etc., shall be in strict accordance with the local Electrical Code requirements. The final connection between the equipment and wiring system shall be made under the direct supervision of a qualified technical representative of the manufacturer.

END OF SECTION

SECTION 27 05 28 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Metal conduits and fittings.
   2. Optical-fiber-cable pathways and fittings.
   3. Hooks.

1.02 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid conduit.

C. IMC: Intermediate metal conduit.

D. RTRC: Reinforced thermosetting resin conduit.

1.03 ACTION SUBMITTALS

A. Product data for the following:
   1. Surface pathways
   2. Wireways and fittings.
   3. Tele-power poles.
   4. Boxes, enclosures, and cabinets.
   5. Underground handholes and boxes.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

C. Samples: For wireways, nonmetallic wireways, and surface pathways and for each color and texture specified, 12 inches long minimum.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
   1. Structural members in paths of pathway groups with common supports.
   2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
   3. Underground ducts, piping, and structures in location of underground enclosures and handholes.

B. Source quality-control reports.

PART 2 PRODUCTS

2.01 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. General Requirements for Metal Conduits and Fittings:
   1. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems". Flexible metal conduit shall not be used.
      a. Outlet boxes shall be no smaller than 4-11/16 inches square and 2-1/2 inches deep.
   2. Comply with TIA-569-D.

2.02 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for plenum, riser, or general-use installation unless otherwise indicated.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

D. Install in 1-inch inner duct.

2.03 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Legrand/Wiremold
2. MonoSystems, Inc
3. Eaton/B-Line
4. Panduit
5. Hubbell

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

E. Stainless steel.

F. J shape.

PART 3 EXECUTION

3.01 PATHWAY APPLICATION

A. Indoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Concealed in Ceilings and Interior Walls and Partitions: EMT
3. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
4. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
5. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway.
6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.

B. Minimum Pathway Size: 1-inch trade size for copper and aluminum cables, and 1 inch for optical-fiber cables.

C. Pathway Fittings: Compatible with pathways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use steel compression fittings. Comply with NEMA FB 2.10.

D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

E. Install surface pathways only where indicated on Drawings.

F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg.

3.02 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 105.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

C. Comply with ANSI/TIA-569-C for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits.

E. Comply with requirements in Section 07 "Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

F. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

G. Complete pathway installation before starting conductor installation.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.

J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Ensure cable pathways are completely and thoroughly cleaned prior to installation of cabling.

M. Abrasion protection:
   1. Provide abrasion protection for cable or wire bundles which pass through holes or across edges of sheet metal.
   2. Use protective bushings to protect cables.
      a. All conduit sleeves larger than 2” shall be fitted with “screw-on” type plastic bushings. Push-on type bushings are permitted on conduits 2” or smaller.

N. Pathways Embedded in Slabs:
   1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
   2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
   3. Arrange pathways to keep a minimum of 1 inch of concrete cover in all directions.
   4. Do not embed threadless fittings in concrete unless specifically approved by Engineer for each specific location.

O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

P. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

R. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
   1. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
   2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

T. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

U. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where an underground service pathway enters a building or structure.
   3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

W. Hooks:
   1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
   2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
   3. Hook spacing shall allow no more than 6 inches of slack. The lowest point of the cables shall be no less than 6 inches adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
   4. Space hooks no more than 4 feet on center.
   5. Provide a hook at each change in direction.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

CC. Set metal floor boxes level and flush with finished floor surface.

3.03 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 "Firestopping."

3.04 LABELING

A. All labeling is to be in accordance with ANSI/TIA-606-B and Wake Tech University's instructions.

B. Handwritten labels are not acceptable.

C. Owner may provide specific labeling requirements. Coordinate with owner.

D. Note labeling information on as-built drawings.

3.05 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.06 GUARANTEE

A. All wiring, etc., shall be in strict accordance with the local Electrical Code requirements. The final connection between the equipment and wiring system shall be made under the direct supervision of a qualified technical representative of the manufacturer.

END OF SECTION

SECTION 27 05 36 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Ladder cable tray.
   2. Wire-mesh cable tray.
   3. Cable tray accessories.
   4. Warning signs.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.
   1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.
   1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
   2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
      a. Vertical and horizontal offsets and transitions.
      b. Clearances for access above and to sides of cable trays.
      c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
      d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
   2. Vertical and horizontal offsets and transitions.
   3. Clearances for access above and to side of cable trays.
   4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Field quality-control reports.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
   1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:
   1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
   2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
   3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.02 LADDER CABLE TRAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Legrand/Cablofil
   2. Chatsworth Products
   3. Eaton/B-Line
   4. Panduit
   5. Hubbell

B. Description:
   1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
   2. Width: 18 inches unless otherwise indicated on Drawings.
   3. Minimum Usable Load Depth: 3 inches.
   4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
   5. Rung Spacing: 9 inches o.c.
   6. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
   7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
   8. No portion of the rungs shall protrude below the bottom plane of side rails.
   9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
   10. Fitting Minimum Radius: 24 inches.
   11. Class Designation: Comply with NEMA VE 1.
   12. Splicing Assemblies: Bolted type using serrated flange locknuts.
   13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
   14. Covers: Solid type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:
   1. Aluminum:
      a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 according to ANSI H35.1/H 35.1M for fabricated parts.
      b. Hardware: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.
      c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.03 WIRE-MESH CABLE TRAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Legrand/Cablofil
   2. Chatsworth Products
   3. Eaton/B-Line
   4. Panduit
   5. Hubbell

B. Description:
   1. Configuration: Galvanized-steel wire mesh, complying with NEMA VE 1.
   2. Width: 18 inches unless otherwise indicated on Drawings.
   3. Minimum Usable Load Depth: 4 inches.
   4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
   5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
   6. Class Designation: Comply with NEMA VE 1.
   7. Splicing Assemblies: Bolted type using serrated flange locknuts.

8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:
1. Steel:
a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
d. Finish: Electrogalvanized after fabrication, complying with ASTM B 633.
1) Hardware: Galvanized, ASTM B 633.

2.04 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.05 WARNING SIGNS

A. Lettering: 1-1/2-inch-high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

2.06 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA VE 2.

PART 3 EXECUTION

3.01 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA VE 2.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Fasten cable tray supports to building structure.

F. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

G. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

I. Support bus assembly to prevent twisting from eccentric loading.

J. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

K. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.

L. Support wire-basket cable trays with trapeze hangers.

M. Support trapeze hangers for wire-basket trays with 1/4-inch-diameter rods.

N. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

O. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.

P. Make changes in direction and elevation using manufacturer's recommended fittings.

Q. Make cable tray connections using manufacturer's recommended fittings.

R. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 "Firestopping."

S. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

T. Install cable trays with enough workspace to permit access for installing cables.

U. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

V. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

W. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

X. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.02 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.03 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

3.04 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
   2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
   3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
   4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
   5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
   6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
   7. Check for improperly sized or installed bonding jumpers.
   8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
   9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.06 PROTECTION

A. Protect installed cable trays and cables.
   1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
   2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
   3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

3.07 GUARANTEE

A. All wiring, etc., shall be in strict accordance with the local Electrical Code requirements. The final connection between the equipment and wiring system shall be made under the direct supervision of a qualified technical representative of the manufacturer.

END OF SECTION

SECTION 27 11 00 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Backboards.
   2. Entrance Protection.
   3. Grounding.
   4. Labeling.

1.02 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. BICSI: Building Industry Consulting Service International.

C. RCDD: Registered communications distribution designer.

D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

E. TGB: Telecommunications grounding bus bar.

F. TMGB: Telecommunications main grounding bus bar.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
   3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
   3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with ANSI/TIA-569-C.

D. Grounding: Comply with ANSI/TIA-607-B.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.07 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
   1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
   2. Record agreements reached in meetings and distribute them to other participants.
   3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
   4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 PRODUCTS

2.01 BACKBOARDS

A. Backboards:
   1. AC grade or better Plywood (grade A side facing interior of room), fire-retardant treated, 3/4 by 48 by 96 inches.
   2. Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry."

2.02 ENTRANCE PROTECTION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CommScope
   2. Emerson Network Power
   3. Circa Enterprises

B. Multi-pair indoor protector panel shall be constructed of metal housing with fire resistant plastic connecting block containing mountings for one hundred (100) protector modules.

C. Protector panel shall include one (1) 25 ft. 26AWG stub cable that shall serve as a fusible link, one (1) 24AWG terminating cable, and two (2) connectors for external ground.

D. Panels shall include cable pass-through capability for side-by-side and top-to-bottom installation.

2.03 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

B. Telecommunications Main Bus Bar:
   1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
   2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.

3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Comply with ANSI/TIA-607-B.

2.04 LABELING

A. Comply with ANSI/TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 EXECUTION

3.01 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Comply with requirements in Section 27 05 28 "Pathways for Communications Systems" for materials and installation requirements for pathways.

C. Install underground entrance pathway complying with Division 26 Section “Raceway and Boxes for Electrical Systems”.

3.02 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in communications equipment spaces.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Coordinate layout and installation of communications equipment in tracks and in room. Coordinate service entrance configuration with service provider.
1. Meet jointly with systems providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize configurations and space requirements of communications equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

G. Backboards:
1. Install from 6 inches to 8 feet, 6 inches above finished floor. If plywood is fire rated, ensure that a fire-rating stamp is visible on each sheet after installation.
2. Paint all sides of backboard with two coats of fire-retardant paint, leaving fire rating stamp visible.
3. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.

3.03 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Firestopping." Comply with ANSI/TIA-569-C, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.04 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI/TIA-607-B.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
   1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.05 GUARANTEE

A. All wiring, etc., shall be in strict accordance with the local Electrical Code requirements. The final connection between the equipment and wiring system shall be made under the direct supervision of a qualified technical representative of the manufacturer.

END OF SECTION

SECTION 27 13 00 - COMMUNICATIONS BACKBONE CABLING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pathways.
   2. UTP cable.
   3. Single Mode, optical fiber cabling.
   4. Coaxial cable.
   5. Cable connecting hardware, patch panels, and cross-connects.
   6. Cabling identification products.

B. Related Sections:
   1. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.03 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.04 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.05 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in ANSI/TIA-568-C.1, when tested according to test procedures of this standard.

1.06 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. For coaxial cable, include the following installation data for each type used:
      a. Nominal OD.
      b. Minimum bending radius.
      c. Maximum pulling tension.

B. Shop Drawings:
   1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.

2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics including the following:
   a. Cross-connects.
   b. Patch panels.
   c. Patch cords.
5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
6. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
   a. Vertical and horizontal offsets and transitions.
   b. Clearances for access above and to side of cable trays.
   c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
   d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For Installer qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings Cabling Administration Drawings, and field testing program development by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
   3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with ANSI/TIA-569-C.

D. Grounding: Comply with ANSI/TIA-607-B.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
   2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
   3. Test each pair of UTP cable for open and short circuits.

1.09 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Patch-Panel Units: One of each type.
   2. Connecting Blocks: One of each type.

PART 2 PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with ANSI/TIA-569-C.

B. Cable Support: NRTL labeled for support of Category 6A cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with cable tie slots for fastening cable ties to brackets.
   2. Lacing bars, spools, J-hooks, and D-rings.
   3. Straps and other devices.

C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."Flexible metal conduit shall not be used.
   1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high and 2-1/2 inches deep.

2.02 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   1. Belden.
   2. Berk-Tek; a Nexans company.
   3. CommScope, Inc.
   4. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
   5. General Cable
   6. Panduit

B. Description: 100-ohm, 4 -pair UTP, in a gray thermoplastic jacket.
   1. Comply with ICEA S-90-661 for mechanical properties.
   2. Comply with ANSI/TIA-568-C.1 for performance specifications.
   3. Comply with ANSI/TIA-568-C.2, Category 6A.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      a. Communications, General Purpose: Type CM or CMG.
      b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
      c. Communications, Riser Rated: Type CMR, complying with UL 1666.

C. Description: 100-ohm, 25 -pair UTP, in a gray thermoplastic jacket.
   1. Comply with ICEA S-90-661 for mechanical properties.
   2. Comply with ANSI/TIA-568-C.1 for performance specifications.
   3. Comply with ANSI/TIA-568-C.2, Category 3.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      a. Communications, General Purpose: Type CM or CMG.
      b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
      c. Communications, Riser Rated: Type CMR, complying with UL 1666.

2.03 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Belden
   2. Berk-Tek; a Nexans Company.
   3. Leviton Voice & Data Division.
   4. Molex Premise Networks; a division of Molex, Inc.

5. Panduit Corp.
6. Tyco Electronics/AMP Netconnect.

B. General Requirements for Cable Connecting Hardware: Comply with ANSI/TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. For MDF, IDF, and other information transport distribution spaces:
1. Provide high density angled 48-Port Category 6A UTP Patch Panels with insulation displacement connecting blocks for termination of all copper backbone cabling.
2. Fixed 110-style insulation displacement connecting blocks shall be used for all ports.
3. Patch Panels shall contain 8-position 568B RJ-45 UTP ports that meet or exceed transmission performance of Category 6A for copper backbone cabling.
4. Patch Panels shall terminate four (4) pairs of Category 6A UTP backbone per jack unless otherwise noted on Project Drawings.

D. Copper Backbone Cabling-Intrabuilding
1. Multi-pair copper backbone cables from the MC located in the MDF shall be home-run routed directly to the racks located in the IDF(s)
2. ISP Copper Backbone Cabling shall be Category 3 rated, 25-pair 24 AWG riser or plenum-rated as required. Cabling shall consist of solid-copper conductors tested to meet Category 3 performance. Cabling shall be UL® tested and listed as CMR or CMP as required for the environment into which it is to be placed.
3. Provide high density angled 24-Port Category 5E UTP Patch Panels with insulation displacement connecting blocks for termination of all copper backbone cabling.
4. Fixed 66-style insulation displacement connecting blocks shall be used for building entrance protector.
5. Patch Panels shall contain 8-position 568B RJ-45 UTP ports that meet or exceed transmission performance of Category 5E for copper backbone cabling.

2.04 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Berk-Tek; a Nexans company.
2. CommScope, Inc.
3. Corning Cable Systems.
4. Tyco Electronics/AMP Netconnect

B. Description: Single Mode, 24-fiber 40/100G, nonconductive, tight buffer, optical fiber cable.
1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with ANSI/TIA-568-C.3 for performance specifications.
3. Comply with ANSI/TIA-492CAAA and ANSI/TIA-492CAAB for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
   b. General Purpose, Conductive: Type OFC or OFCG
   c. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
   d. Riser Rated, Conductive: Type OFCR, complying with UL 1666.
5. Conductive cable shall be aluminum armored type.
6. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

C. Description: 6-strand, Multi-Mode 62.5 micron, 40/100G, nonconductive, tight buffer, optical fiber cable.
1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA/EIA-492AAAA-B and TIA/EIA-492AAAA-A for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.

b. General Purpose, Conductive: Type OFC or OFCG
c. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
d. Riser Rated, Conductive: Type OFCR, complying with UL 1666.

5. Conductive cable shall be aluminum armored type.
6. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
8. Cable shall be suitable for direct burial usage. Provide SC type terminations and terminate all fibers at each end of the cable.

D. Optical Fiber Backbone Cabling:
1. The cable shall be listed OFNR (OFCR) for riser (non-plenum) applications or OFNP (OFCP) for plenum applications, as required. The indoor backbone fiber shall be a hybrid/composite multi-mode and single mode, utilizing a tight buffered, air-core design with all-dielectric strength member construction and outer jacket. Outdoor cable shall be of a loose buffer tube 100% dielectric design, utilizing a UV stabilized, flame retardant outer jacket.
2. Orange innerduct shall be required with all optical fiber cabling; indoor and outdoor. All conduit designated to contain interbuilding and outside plant (OSP) optical fiber shall also be filled with spare innerducts comprising the full capacity of that conduit. For example, a 4” OSP conduit shall contain a minimum of (3) 1” innerducts in all cases the cabling installation requires use of the conduit. Un-used conduits shall be left vacant.
3. Minimum bend radius shall be no less than fifteen (15) times outside diameter under full tensile load and no less than ten (10) times outside diameter under no load.
4. New Single Mode Optical Fiber segments shall meet the requirements of EIA/TIA-492CAAB “Detail Specification for Class 1va Dispersion-un-shifted Single Mode Optical Fibers with Low Water Peak” and ITU recommendation G.652.C, “Characteristics of a Single Mode Optical Fiber Cable.”

E. Backbone (riser) cable in non-plenum air spaces shall be NEC Type OFNR as follows:
1. 900 µm tight buffered Fan-Out Riser Cable.

F. Backbone (riser) cable in plenum air spaces shall be NEC Type OFNP as follows::
1. 900 µm tight buffered Fan-Out Riser Cable.

G. Optical Fiber Connections:
1. All optical fiber cables shall be terminated with permanently installed connectors per EIA/TIA-45 S-21.
2. Optical fiber connections shall utilize “SC” type connectors with ceramic ferrule and bend limiting strain relief.
3. The maximum optical attenuation for each rated connector pair shall not exceed 0.7 dB.
4. The connectors shall sustain a minimum of two-hundred (200) mating cycles without violating performance requirements as outlined in EIA/TIA 568B.3.
5. Factory terminated lengths of optical fiber with “SC” connectors shall not be used for backbone or horizontal cabling. Field termination of “SC” connectors for multimode and single mode shall be allowed.
6. Connectors shall be color coded according to the optical fiber type for which they are applied. 8.3/125µm single mode shall be green, and laser-optimized 50/125µm multimode shall be aqua.

H. Jacket:
1. For indoor applications, the color of the outer jacket shall be orange for cables containing 62.5/125 µm fiber
2. For indoor applications, the color of the outer jacket shall be yellow for cables containing single mode fiber
3. For outside plant applications, the jacket shall contain carbon black to provide ultraviolet light protection
4. Jacket Color: Aqua for 50/125-micrometer cable and Orange for 62.5/125-micrometer cable.

5. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
6. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.05 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Berk-Tek; a Nexans company.
   2. CommScope, Inc.
   3. Corning Cable Systems.
   4. Tyco Electronics/AMP Netconnect.
   5. Siemon Co. (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
   1. Optical Fiber Distribution Panels shall be rack mount enclosures with front and rear removable doors, removable top, large front-mounted fiber guides, and integrated hinged optical jumper manager. “72-Port” panels shall accept up to twelve (12) connector panels, supporting a maximum of seventy-two (72) “SC” style couplings in 4U rack space. Each panel shall include a full complement of blank adapter panels, labels, cable storage accessories, and optical fiber cable routing accessory kit.
   2. Optical Fiber Distribution Panels shall include simplex “SC” style coupler panels and connectors as required for the complement of multimode and single mode optical fiber elements, indicated on Project Drawings.
   3. Multimode Connector Panels shall each contain six (6) “SC” style simplex adapters and shall be color coded according to the optical fiber type for which they are applied. Multimode terminations should be indicated with a black dust cap.
   4. Single Mode Connector Panels shall each contain six (6) “SC” style simplex adapters and shall be color coded according to the optical fiber type for which they are applied. Single Mode terminations should be indicated with a yellow dust cap.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:
   1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with ANSI/TIA-568-C.3.
   2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.

2.06 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

B. Comply with ANSI/TIA-607-B.

2.07 IDENTIFICATION PRODUCTS

A. Comply with ANSI/TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.08 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to ANSI/TIA-568-C.1.

C. Factory test UTP cables according to ANSI/TIA-568-C.2.

D. Factory test multimode optical fiber cables according to TSB-140 and ANSI/TIA-568-C.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 EXECUTION

3.01 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.02 WIRING METHODS

A. Wiring Method: Refer to Telecom Riser diagram on the drawings as to which wiring method shall be used on this project.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.03 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and ANSI/TIA-569-C.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with ANSI/TIA-569-C for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room from overhead.
   4. Extend conduits 3 inches above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.04 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   1. Comply with ANSI/TIA-568-C.1.
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
1. Comply with ANSI/TIA-568-C.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:
1. Comply with ANSI/TIA-568-C.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Outdoor Coaxial Cable Installation:
1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:
1. Comply with BICSI TDMM and ANSI/TIA-569-C recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.05 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."Comply with ANSI/TIA-569-C, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.06 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI/TIA-607-B.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.07 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with ANSI/TIA-606-B. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
   1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion about TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with ANSI/TIA-606-B for Class 2 level of administration including optional identification requirements of this standard.

D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:
   1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
   3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
   4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
      a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
      b. Label each unit and field within distribution racks and frames.
   5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in ANSI/TIA-606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with ANSI/TIA-568-C.1.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
      a. Test instruments shall meet or exceed applicable requirements in ANSI/TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   4. Optical Fiber Cable Tests:
      a. Test instruments shall meet or exceed applicable requirements in ANSI/TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Link End-to-End Attenuation Tests:
         1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
         2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in ANSI/TIA-568-C.1.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.09 GUARANTEE

A. All wiring, etc., shall be in strict accordance with the local Electrical Code requirements. The Contractor shall guarantee all equipment and wiring free from inherent mechanical and electrical defects for a period of one (1) year from date of installation. The final connection between the equipment and wiring system shall be made under the direct supervision of a qualified technical representative of the manufacturer.

END OF SECTION

SECTION 27 15 13 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Category 6A twisted pair cable.
   2. Twisted pair cable hardware, including plugs and jacks.
   3. Multiuser telecommunications outlet assembly.
   4. Cable management system.
   5. Cabling identification products.
   6. Grounding provisions for twisted pair cable.
   7. Source quality control requirements for twisted pair cable.

B. Related Requirements:
   1. Section 27 15 13 "Communications Copper Horizontal Cabling” for data cabling associated with system panels and devices.

1.02 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

B. EMI: Electromagnetic interference.

C. FTP: Shielded twisted pair.

D. F/FTP: Overall foil screened cable with foil screened twisted pair.

E. F/UTP: Overall foil screened cable with unscreened twisted pair.

F. IDC: Insulation displacement connector.

G. LAN: Local area network.

H. Jack: Also commonly called an "outlet," it is the fixed, female connector.

I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

J. RCDD: Registered Communications Distribution Designer.

K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

M. S/FTP: Overall braid screened cable with foil screened twisted pair.

N. S/UTP: Overall braid screened cable with unscreened twisted pairs.

O. UTP: Unscreened (unshielded) twisted pair.

1.03 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
   1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
   2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
   3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 277 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.
   1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
   2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
   3. Cabling administration Drawings and printouts.
   4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
      a. Telecommunications rooms plans and elevations.
      b. Telecommunications pathways.
      c. Telecommunications system access points.
      d. Telecommunications grounding system.
      e. Telecommunications conductor drop locations.
      f. Typical telecommunications details.
      g. Mechanical, electrical, and plumbing systems.

C. Twisted pair cable testing plan.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On USB media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Connecting Blocks: One of each type.
   2. Faceplates: Five of each type.
   3. Jacks (RJ45): Ten of each type.
   4. Multiuser Telecommunications Outlet Assemblies: One of each type.
   5. Patch-Panel Units, fully loaded with jacks: One of each type.
   6. Plugs: Ten of each type.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
   3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test each pair of twisted pair cable for open and short circuits.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.11 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.12 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Final Acceptance. Install and program software upgrades that become available within two years from date of Final Acceptance. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.02 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
   1. Communications, Plenum Rated: Type CMP complying with UL 1685.
   2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
   3. Communications, Non-plenum: Type CMR complying with UL 1666.
   4. Communications, Non-plenum: Type CMP or Type CMR in listed plenum or riser communications raceway.
   5. Communications, Non-plenum: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

C. RoHS compliant.

2.03 CATEGORY 6A TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6A cable at frequencies up to 250MHz.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. 3M.
   2. AMP NETCONNECT; a TE Connectivity Ltd. company.
   3. Belden.
   4. Berk-Tek Leviton; a Nexans/Leviton alliance.
   5. CommScope, Inc.
   6. General Cable; Prysmian Group North America.
   7. Genesis Cable Products; Honeywell International, Inc.
   8. Hitachi Cable America Inc.
   9. Mohawk; a division of Belden Networking, Inc.
   10. Prysmian Cables and Systems; Prysmian Group North America.
   11. Superior Essex Inc.
   12. SYSTIMAX Solutions; a CommScope Inc. brand.

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6A cables.

D. Conductors: 100-ohm, 23 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP).

F. Cable Rating: Plenum.

G. Jacket: Gray thermoplastic.

2.04 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. 3M.
   2. American Technology Systems Industries, Inc.
   3. AMP NETCONNECT; a TE Connectivity Ltd. company.
   4. Belden.
   5. Berk-Tek Leviton; a Nexans/Leviton alliance.
   6. CommScope, Inc.
   7. Dynacom Corporation.
   8. General Cable; Prysmian Group North America.
   9. Genesis Cable Products; Honeywell International, Inc.
   10. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
   11. KRONE Incorporated.
   12. Leviton Manufacturing Co., Inc.
   13. Mohawk; a division of Belden Networking, Inc.
   14. Molex Premise Networks.
   15. Panduit Corp.
   16. Prysmian Cables and Systems; Prysmian Group North America.
   17. Siemon Co. (The).
   18. Superior Essex Inc.
   19. SYSTIMAX Solutions; a CommScope Inc. brand.

C. General Requirements for Twisted Pair Cable Hardware:
   1. Comply with the performance requirements of Category 6A.
   2. Comply with TIA-568-B, IDC type, with modules designed for punch-down caps or tools.
   3. Cables shall be terminated with connecting hardware of same category or higher.

D. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.

E. Connecting Blocks:
   1. 110-style IDC for Category 6A.
   2. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
   1. Number of Terminals per Field: One for each conductor in assigned cables.

G. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
   1. Features:
      a. Universal T568A and T568B wiring labels.
      b. Labeling areas adjacent to conductors.
      c. Replaceable connectors.
      d. 24 or 48 ports.
   2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
   3. Number of Jacks per Field: One for each four-pair [cable indicated] [conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria].

H. Patch Cords: Factory-made, four-pair cables in 48-inch lengths; terminated with an eight-position modular plug at each end.
   1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
   2. Patch cords shall have color-coded boots for circuit identification.

I. Plugs and Plug Assemblies:
   1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
   2. Standard: Comply with TIA-568-B.
   3. Marked to indicate transmission performance.

J. Jacks and Jack Assemblies:
   1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
   2. Designed to snap-in to a patch panel or faceplate.
   3. Standard: Comply with TIA-568-B.
   4. Marked to indicate transmission performance.

K. Faceplate:
   1. Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
   2. Twelve port, vertical double gang faceplates designed to mount to double gang wall boxes.
   3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 26 27 26 "Wiring Devices."
   4. .
   5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

L. Legend:
   1. Machine printed, in the field, using adhesive-tape label.
   2. Snap-in, clear-label covers and machine-printed paper inserts.

2.05 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Belden.

2. Chatsworth Products, Inc.
3. Hubbell Premise Wiring; Hubbell Incorporated, Commercial and Industrial.
4. Molex Premise Networks.
5. Ortronics, Inc.
6. Panduit Corp.
7. Siemon Co. (The).

B. Description: MUTOAs shall meet the requirements of "Twisted Pair Cable Hardware" Article.
1. Number of Terminals per Field: One for each conductor in assigned cables.
2. Number of Connectors per Field:
   a. One for each four-pair unshielded or shielded twisted-pair cable indicated.
   b. One for each four-pair unshielded or shielded twisted-pair group of indicated cables, plus 25 percent spare positions.
3. Mounting: Wall.
4. NRTL listed as complying with UL 50 and UL 1863.
5. Label shall include maximum length of work area cords, based on TIA-568-C.1.
6. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.06 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.07 GROUNDING

A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.08 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568-C.1.

C. Factory test twisted pair cables according to TIA-568-C.2.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 EXECUTION

3.01 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal raceway and cables, except in unfinished spaces.
1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 27 05 28 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.02 INSTALLATION OF PATHWAYS

A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 27 11 00 "Communications Equipment Room Fittings."

B. Comply with Section 27 05 28 "Pathways for Communications Systems."

C. Comply with Section 26 05 29 "Hangers and Supports for Electrical Systems."

D. Comply with Section 27 05 36 "Cable Trays for Communications Systems."

E. Drawings indicate general arrangement of pathways and fittings.

3.03 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:
   1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
   2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
   5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   6. MUTOA shall not be used as a cross-connect point.
   7. Consolidation points may be used only for making a direct connection to equipment outlets:
      a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      b. Locate consolidation points for twisted-pair cables at least 49 feet from communications equipment room.
   8. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   9. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
   10. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual , Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
   11. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
   12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
   13. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
   14. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
   15. Plastic tie wraps are not permitted during or after installation. Only velcro tie wraps are allowed,

C. Open-Cable Installation:
   1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
   3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:
   1. Install plenum-rated cable only.
   2. Install cabling after the flooring system has been installed in raised floor areas.

3. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:
1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.04 FIRESTOPPING

A. Comply with requirements in Section 07 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.05 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.06 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified during the Pre-Installation Meeting.
1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B.

C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

E. Cable and Wire Identification:
   1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
   3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
   4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
      a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
      b. Label each unit and field within distribution racks and frames.
   5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
   1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Tests and Inspections:
   1. The contractor shall test UTP cable in accordance with TIA-568-C series standards, including TIA-568-C.0, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-568-C.4, and TSB-140. Each UTP cable shall be tested and the results documented and delivered to the owner's representative for review/acceptance.
   2. Copper cabling shall be fully tested for Cat6A compliance in the TIA specifications, including the following parameters:
      a. DC resistance
      b. Open pairs Shorted pairs Split pairs
      c. Reversed conductors
      d. NEXT (test from both ends)
      e. ELFEXT
      f. Return loss
      g. Delay skew

E. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

F. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

G. End-to-end cabling will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.08 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Final Acceptance, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

END OF SECTION

SECTION 27 41 00 - AUDIO-VIDEO SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. General: When a discrepancy arises between the below-mentioned codes, standards or guidelines and the standards contained in this document, it shall be brought to the attention of the owner immediately for resolution. The more stringent of the two guidelines shall be implemented.
   1. The following codes, associations, acts and agencies, as required by law:
      a. Americans with Disabilities Act (ADA)
      b. Federal Communications Commission (FCC)
      c. NFPA-70, 2014 (National Electric Code)
      d. National Electrical Safety Code (NESC)
      e. Occupational Safety and Health Administration (OSHA)
   2. The current edition of the following standards:
      a. National Electrical Manufacturers Association (NEMA)
      b. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
      c. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
      d. ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standard
      e. ANSI/TIA-568-C.3, Optical Fiber Cabling Components Standard
      f. ANSI/TIA-568-C.4, Broadband Coaxial Cabling and Components Standard
      g. AVIXA A102.01:2017, Audio Coverage Uniformity
      h. ANSI/AVIXA D401.01:201X, Standard Guide for Audiovisual Systems Design and Coordination Process
      i. V201.01:2021, Image System Contrast Ratio
      j. AVIXA S601.01:2021, Energy Management for Audiovisual Systems
      k. AVIXA 10:2013, Audiovisual Systems Performance Verification
      l. AVIXA F501.01:2015, Cable Labeling for Audiovisual Systems
      m. AVIXA F502.01:2018, Rack Building for Audiovisual Systems
      n. AVIXA F502.02:201X, Rack Design for Audiovisual Systems3.
   3. The current edition of the following guidelines:
      a. BICSI, Telecommunications Distribution Methods Manual (TDMM)
      b. InfoComm, AV Installation Handbook
      c. AVIXA RP-C303.01:2018 Recommended Practices for Security in Networked AV Systems

1.02 WORK INCLUDED

A. The work covered by this specification includes the installation of a complete and fully functional system, including all labor necessary to perform and complete such installation, all materials and equipment incorporated or to be incorporated in such installation, and all services, supervision, consumable items, fees, licenses, facilities, tools, and equipment necessary or used to perform and complete such installation.

B. The contractor shall provide all elements of turnkey audiovisual systems including the creation of control system and digital signal processor programming files and final loading and testing of such systems. The contractor shall perform all basic equipment configuration.

C. The installing contractor shall be responsible for the following.
   1. Unless otherwise specified, supply only new equipment, parts, and material, and protect all equipment from construction dust and debris until final acceptance.
   2. The System Drawings indicate the general layout of the various items of equipment and their functional relationships. Section 27 41 16, which provides a system description and equipment list. Layout of equipment, accessories, and conduit systems are diagrammatic unless specifically detailed and do not necessarily indicate every item required for a

complete installation. It is the responsibility of the contractor to review system drawings and equipment lists and to provide any incidental equipment needed in order to result in a complete and operable system even if not specified or shown on drawings without claim for additional payment.

3. Refer to audiovisual floorplans, elevations, and conduit drawings for receptacle backbox location and quantity information. Also, refer to architectural reflected ceiling plans for exact location of ceiling-mounted devices.
4. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.
5. Obtain all permits necessary for the execution of the work. Comply with all applicable local codes and regulations.
6. Provide inserts, cover plates and accessories as required for a complete system.
7. Supply and install miscellaneous steel, such as Uni-strut and threaded rod for ceiling mounted equipment.
8. Provide project management and oversight for the installation of a complete audiovisual system.
9. Prepare and submit component documentation shop drawings, outlet labeling drawings, cable pull/termination schedules, cable test results and record or as-built drawings, manufacturer cut sheets and other documentation described herein.
10. Verification of accuracy and completeness of equipment lists, dimensions, mounting details and equipment compatibility.
11. One-year warranty of the equipment and installation from the date of owner acceptance.
12. Test equipment, tools, ladders, lifts, and scaffolding required for installation.
13. Daily and final cleanup of debris caused by installation.
14. Quality Control / Commissioning of system with the owner.

D. Definitions
1. Owner: Wake Tech Community College
2. Architect: Lord Aeck Sargent
3. Consultant: BrightTree Studios
4. Audiovisual Contractor or Contractor: Company responsible for work under this section.
5. Install: provide, store, unpack, and securely attach or mount equipment to structure following industry standards, approved shop drawings, and manufacturer recommendations.
6. Installation Materials: Installed cable, loose cable, terminations, cable management, voice/data/video patch cords, adapters, I/O Panels, cable dressing, lacing bars, copper bus bars, labels, rack shelves, rack mounts, power strips/distribution and other materials as needed to install the systems.
7. Construction Area: Those areas identified on drawings, specifications, and contract documents as well as areas affected by the work including all areas of the building.
8. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system. Assume all spaces above suspended or accessible ceilings are a plenum.
9. Plenum-rated: Listed by the Underwriters Laboratory as being suitable for installation into a plenum space. Communications cabling routed through plenum-rated space shall be plenum-rated and identified as Type CMP.

E. Abbreviations and Acronyms
1. A/E: Architect/Engineer (designer)
2. ADA: Americans with Disabilities Act
3. AFC: Above Finished Ceiling
4. AFF: Above Finished Floor
5. AHJ: Authority Having Jurisdiction
6. ALS Assisted Listening System
7. ANSI: American National Standards Institute
8. BISCI: Building Industry Consulting Service International

9. BTU: British Thermal Unit
10. CATV: Community Antenna Television (Cable Television).
11. CMP: Communications Plenum Cable
12. CMR: Communications Riser Cable
13. DSP Digital Signal Processor
14. dB: Decibel
15. dBmV: Decibel Millivolt
16. EIA: Electronic Industries Association
17. FCC: Federal Communications Commission
18. FOMM: Fiber Optic Multimode
19. FOSM: Fiber Optic Single Mode
20. F/UTP: Foil Screened Unshielded Twisted Pair
21. FREQ: Frequency
22. GHz: Gigahertz
23. Hz: Hertz
24. IEEE: Institute of Electrical and Electronics Engineers
25. ISO: International Standards Organization
26. IT: Information Technology
27. LAN: Local Area Network
28. LC: Lucent Connector
29. Mbps: Megabits per second
30. MHz: Megahertz
31. MM: Multimode
32. MMF: Multimode Fiber
33. OFNP: Optical Fiber Nonconductive Plenum Cable
34. OFNR: Optical Fiber Nonconductive Riser Cable
35. OSHA: Occupational Safety and Health Administration
36. PoE: Power-over-Ethernet
37. RCDD: Registered Communications Distribution Designer
38. RFI: Radio Frequency Interference
39. SC: Subscriber Connector
40. ScTP: Screened Twisted Pair
41. STP: Shielded Twisted Pair
42. SM: Single Mode
43. SMF: Single Mode Fiber
44. TIA: Telecommunications Industry Association
45. UL: Underwriters Laboratory
46. UPS: Uninterruptible Power Supply
47. UTP: Unshielded Twisted Pair
48. VLAN: Virtual LAN

1.03 SUBMITTALS

A. General
1. Provide submissions as described in this specification. Those submissions include:
   a. Shop Drawings
   b. Bill of Materials (BOM)
   c. Test Reports
   d. As-built drawings and close-out documentation
2. Delivery Schedule
   a. Shop drawings shall be submitted in advance of construction so as to cause no delay in work. Shop drawings shall be submitted at such time to allow the engineer reasonable time to review shop drawings to make necessary corrections. Shop drawings shall consist of, but not be limited to:
      1) Drawing Index and Title Page

2) Symbol Legend
3) Floor plan and reflected ceiling plan showing layout of audiovisual devices, equipment that indicate equipment types, model numbers, a unique identifier for each piece of equipment, connector types and genders, cable type, and cable numbers.
4) Rack Elevations
5) Video Projectors: Provide a table that identifies the projector type, lens type, screen size and acceptable lens throw distance.
6) Provide detailed drawings of custom-fabricated mounts & panels.
7) For patch panel locations to be built with commercial off the shelf parts, provide a detailed parts list and specifications for each part.
8) Cable pulls list defining cable types, quantities, locations, and label information

3. Bill of material submission:
   a. Bill of materials
   b. Manufacturer product data sheets
   c. Indicate all selected options, accessories, and colors on either the bill of materials or product data sheets. If different options are selected for different rooms or locations, provide a table indicating location, product, and option selections.
   d. IP Table for all Network devices: No later than 30 days prior to beginning installation. Following coordination with the owner's control system programmer, provide a .xls file listing for each network device:
      1) System #
      2) System Name
      3) Manufacturer
      4) Model #
      5) Location
      6) Serial #
      7) MAC Address
      8) IP Address
      9) Subnet
      10) VLan Name/Number
      11) Default gateway
      12) Primary DNS
      13) Secondary DNS
      14) Firmware Version
      15) Control System ID.
   e. Provide similar information for non-ethernet network devices such as RS-485 including relevant information such as device ID, baud rate, etc.
4. Test result submission: One week before acceptance testing provide the following:
   a. System test and certification reports
   b. Completed IP Table as listed above in 'Shop Drawing Submission'
   c. Draft of "as-built" system diagrams. Electronic version to be sent to Owner and Consultant 1 week before acceptance testing.
   d. Documentation of performance test results.
   e. Documentation of the system settings prior to and after the system start-up.
   f. Provide drawings showing all equipment components, and wires. Label all devices with manufacturer, model number, and instance number.
   g. As-built drawings are to include full connection information for each termination of conductors within a cable, either on the drawing itself via cable breakouts or by designating the connection type and providing separate details for each connection type.
   h. Provide layout drawings of panels and other custom assemblies.

i. On wiring diagrams, label all conductors within cables for insulation color or other identifier. Label connectors, barrier strips, switches, relay sockets, etc., for terminal number.

5. AS-Built Submission
   a. Completed IP Table as listed above in ‘Shop Drawing Submission’
   b. As-built drawings and closeout documentation: Within 30 days after final acceptance testing visit provide the following:
      1) "As-Built/Record drawings, in AutoCAD and PDF format, consisting of Floor Plans, Reflected Ceiling Plans, System Block drawings, Rack Elevations, and Wall and Rack Plate details.

1.04 QUALITY ASSURANCE

A. Project Management: Maintain the same person in charge of work throughout installation.

B. Contract Documents: Maintain a complete set of system drawings and specifications at the site during installation.

C. Fabrication and Installation: Completely fabricate all equipment racks and subassemblies in contractor fabrication shop.

D. Contractor Qualifications:
   1. Lead AV Designer:
      a. Shall have a current AVIXA Certified Technology Specialist - Installation (CTS-D) certification in good standing.
      b. Shall provide all quality control (QC) and safety inspections as needed throughout the installation.
      c. Shall conduct all AV system commissioning tests, and proof-of-performance testing/demonstration.
   2. Lead Field Technician:
      a. Shall have a current AVIXA Certified Technology Specialist - Installation (CTS-I) certification in good standing.
      b. Shall provide all quality control (QC) and safety inspections as needed throughout the installation.
      c. Shall conduct all AV system commissioning tests, and proof-of-performance testing/demonstration.
   3. On-Site Support Personnel :
      a. CTS Preferred
   4. Programmer
      a. The control systems programmer assigned to the project shall be certified by the manufacturer.
      b. Audio DSP programmer assigned to the project shall have manufacturer’s training and certification for specified system.

1.05 SEQUENCING

A. Coordinate work with adjacent work of other trades to facilitate construction and prevent conflicts.

1.06 WARRANTY

A. To maintain certain manufacturer’s warranties, equipment must be installed, aligned, and serviced by those installers authorized by that manufacturer to perform those duties. If the Contractor is not authorized, by the manufacturer, it is the Contractor’s sole responsibility to make the appropriate arrangements and bear all cost and consequences.

B. In case where the manufacturer’s warranty period is greater than specified in this Section, the Contractor shall provide that warranty for the full extent of the manufacturer’s warranty period.

C. All manufacturers’ equipment warranties shall be activated in the Owner’s name and shall commence on the date of final acceptance.

D. In the case of Contractor-modified equipment, the manufacturer's warranty is normally voided. In such cases, the Contractor shall provide the Owner with a warranty equivalent to that of the original manufacturer.

E. In the event of malfunction or failure of any audiovisual equipment provided by the Contractor, the Contractor shall be responsible for replacement of faulty equipment or providing "loaner" equipment at no cost to the Owner for the duration of the repairs. In the event that "loaner" equipment is provided, said equipment shall meet or exceed the original equipment's specifications until the original equipment is replaced.

F. In cases where the Contractor is providing and installing audiovisual equipment and/or hardware to be integrated with equipment furnished by others, it shall be the responsibility of the Contractor to warrant their equipment as described in the Contract Documents unless said equipment shows misuse and or abuse by others during re-installation or connection of equipment by others.

G. Equipment shall be serviced within 24 hours of first notification. If repairs cannot be completed during this time period, or if ordering of parts is required, the Owner shall be notified every 72 hours documenting progress of repairs. This repair capability is mandatory. Include costs anticipated to comply with this requirement in the bid.

1.07 SERVICE CONTRACT

A. Provide a one-year service contract to commence after acceptance of installation without additional cost. Service to include two semi-annual visits to the site for routine adjustment and maintenance of all equipment. Provide a preliminary schedule for the semiannual visits.

1.08 INSPECTION

A. Notify the Architect of any defects in work by other trades affecting installation.

PART 2 PRODUCTS

2.01 GENERAL

A. Refer to the specific section 27 41 16 for equipment requirements.

2.02 MATERIALS AND EQUIPMENT

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are available.

B. All products and materials shall be new and unused, clean, free of defects, and free of damage or corrosion prior to their installation as part of this project. Refurbished items are not allowed.

C. Used or damaged equipment or material is not allowed.

D. Materials shall bear UL label where applicable. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are available.

E. Stock manufactured or custom-built equipment shall be supported by complete and detailed schematic drawings and replacement parts list. No unidentified components shall be acceptable.

2.03 WIRE AND CABLES

A. See Section 27 41 16 Integrated Audio-Video Systems and Equipment for cable specifications.

B. Cable passing through two or more floors shall be Rated listing and marked for use in riser applications.

C. Riser Cable shall be CMR or OFNR rated per NEC and comply with applicable codes.

D. Cable in Plenums shall be Rated listing and marked for use in plenum applications.

E. Plenum Cable shall be CMP rated per NEC and comply with applicable codes.

F. Contractor shall verify all spaces as plenum or non-plenum with the architect/mechanical engineer prior to purchasing or installing cable.

G. It is the responsibility of the contractor to comply with all plenum requirements of the Owner and the Authority Having Jurisdiction (AHJ) for all cables.

2.04 MISCELLANEOUS

A. Contractor shall provide all screws, anchors, clamps, miscellaneous grounding, and support hardware necessary for installation of the system(s).

B. Contractor shall furnish special installation equipment or tools necessary to properly complete the system(s). This may include, but limited to, tools for terminating cables, test equipment, jack stands for cable reals, and cable wrenches.

C. Any Owner-Furnished Contractor Installed (OFCI) Equipment on-site shall be removed, cleaned, test for proper operation and install in accordance with project guidelines. Any OFCI Equipment provided for project shall be installed in accordance with project guidelines.

D. Coordinate the return or recycling of removed and/or replaced equipment with the Owner. Existing equipment not reused shall be returned to the Owner. The Contractor is required to properly recycle or dispose of equipment at no additional cost to the Owner upon request.

E. All cabling within equipment racks will be managed using hook and loop fasteners (Velcro).

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall conduct coordination meetings with the Owner’s audio-visual and information technology support staff following bid award to coordinate system configuration, network settings, etc.

3.02 LABELS

A. Except where otherwise specified, label as shown on drawings and as specified each item of rack mounted equipment, all switches, controls, and receptacles.

B. Receptacles: Engrave and fill receptacle label directly on mounting plate as indicated on Contract Drawings.

C. Identify all wires and cables at every termination and connection point with the specified cable markers. The contractor is strongly encouraged to use a numbering scheme that identifies all cables terminating at patch panel jacks with the patch bay row and jack designation; use A, B, and suffixes to distinguish multiple cables terminating at the same jack.

D. All labels and legends shall be as approved on shop drawings.

E. Cable Markers:
   1. High-grade PVC clip-on or permanent-type cable markers with permanent markings, or printed vinyl tape protected by clear shrink tubing or adhesive wrap.

3.03 TESTING AND VERIFICATION

A. Refer to individual sections for additional testing and verification requirements.

B. Contractor will complete all testing for system operational compliance, and test to ensure all equipment is working fully published specifications.

C. A physical inventory will be taken of all equipment on site and will be compared to equipment lists in the contract documents and subsequent Contractor submittals.

D. The Contractor shall demonstrate the operation of all system equipment.
   1. The Contractor shall be responsible for providing test equipment for these tests.
   2. The Contractor shall be responsible for providing qualified personnel to run tests, make adjustments, and answer system questions accomplish the tests and setup satisfactory.

E. The Contractor shall be responsible for providing the personnel that accomplished all device configuration for the system. This person will be available to run requested demonstration, make adjustments, and answer installation and configuration questions for as long as required to accomplish the demonstration satisfactorily.

F. In the event there is required rework, large scale readjustments, or defective equipment that must be repaired or replaced, tests may be suspended or continued at the option of the Owner. The Owner will advise if training can commence while any further cleanup is being done before Completion.

3.04 FINAL ADJUSTMENTS AND ACCEPTANCE TESTS

A. Assist the consultant and owner in performing final system adjustments and acceptance tests. Provide all labor, material, tools, and measurement equipment necessary for these tests and adjustments.

B. The contractor shall supply sufficient representatives for assisting in performance of these tests, all of which shall be thoroughly familiar with all details of the system and shall include the field supervisor in overall charge during the course of the installation work.

C. Adjustments: Adjust the system as instructed by the consultant and owner.

3.05 PROGRESSIVE AND FINAL CLEANING OF PROJECT SITE

A. Remove dust and debris from interior and exterior of audiovisual equipment. Clean accessible current carrying equipment prior to being energized.

B. Upon completion of the work, remove excess debris, materials, equipment, tools, and similar items. Leave the premises clean, neat, and orderly.

3.06 COMPLETION

A. Systems shall be complete and operational including the completion of owner performed programming work.

B. Testing, start-up, and cleaning work shall be complete.

C. Contractor will accomplish a complete system(s) inventory of all equipment, and inspection of all workmanship quality relating to installation details.

END OF SECTION

SECTION 27 41 16 - INTEGRATED AUDIO-VIDEO SYSTEMS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This section provides descriptions of audiovisual systems, special notes regarding installation, and establishes minimum functionality. The contractor is responsible for ensuring the audiovisual systems meet the minimum functionality described here and any functionality implied or necessary for operation of the audiovisual systems.

B. Unauthorized deviations from these Specifications may result in re-design, reconstruction, or re-installation of physical communications elements at the Contractor's expense. Contractors shall obtain formal written approval prior to installation to deviate from these specifications.

1.02 GENERAL

A. Projection
   1. Refer to the TA series drawings for locations.
   2. Projectors shall be laser projectors. The projectors shall be installed at a distance from the screen so the projected image shall completely fill the screen with the projector's zoom range at its center setting. Ceiling mounts shall be, high quality, professional grade. The color shall match the projector. The mount shall have a locking arm that secures the projector to the base plate. The projector mount shall have adjustable settings. The projector ceiling brackets shall be mounted per the manufacturers' specifications and adhere to all building codes.
   3. In classroom spaces the projector(s) shall be ceiling mounted. The cutout, strut mounting, above ceiling plenum storage box, and projector mount plate are provided by others. The AV contractor shall provide a pipe column extension, the projector mount, and projector.
   4. All projector installations require verification of throw distance and mounting height by the contractor to ensure the proper lens and pipe column extension are used.

B. Equipment Racks
   1. Racks shall fill no more than 80% of the rack to allow for future growth, as well to provide proper air flow and heat exhaustion. 120V power conditioners shall be provided with power overload switches. Power conditioners shall have no more than 80% of load used. Load calculations are to be included in all project designs along with BTU calculations.
   2. Racks located in cabinetry shall have rear access in the form of a lockable door. The lock shall adhere to the AV standard (100T). All cabinets shall be keyed alike with 2 keys for each rack installed and be provided to WTCC ITS AV. If rear access cannot be accommodated, the cabinet shall allow for a sliding rack to be easily mounted for servicing. There shall be sufficient width and depth for the rack and loop of cables.

C. Lecterns
   1. Lecterns shall be specified in coordination with WTCC ITS AV. Equipment shall be mounted in a 19" wide rack, within the lectern assembly. Lectern designs shall include a lockable section and be keyed to restrict access. Suitable cable paths throughout the lectern shall be given. Power and network connections shall be supplied inside the lectern. Cable pathways for the lectern shall have sufficient capacity to accommodate all signal cable and take future expansion into consideration.

D. AV Control
   1. WTCC ITS AV control equipment standard is based on Extron Control.

E. AV Switching
   1. WTCC basis of design switching equipment is Extron for typical spaces. Any space designated to be converted from analog to digital, or configured to output High-Definition, shall require the use if a HDCP compliant. At minimum, the switcher shall include
      a. HDCP compliance with full key management on all inputs and outputs
      b. EDID management

c. Scaling/frame rate conversion
d. HDMI audio embedding and de-embedding
e. 1920x1080@60Hz
f. Color space management

F. Web Based Collaboration Solution
1. WTCC has standardized on Microsoft TEAMS as the web based/soft conferencing solution. Dedicated hardware shall be required in teaching and meeting rooms that offer web collaboration through TEAMS. For rooms with no more than 12 people a USB webcam and echo cancelling speakerphone is recommended. For medium and large rooms, a dedicated DSP with AEC shall be used along with high quality speakers and microphones.

G. Network and Security Infrastructure requirements
1. Registration of devices shall be managed by WTCC ITS AV. All devices shall be deployed with the latest available firmware installed and documented along with the serial numbers and MAC addresses or each box installed. Non-approved ITS data switches of any kind are not to used.

H. Cabling
1. All cabling shall be neat and secure, where equipment is mounted on slides, sufficient cable length shall be supplied to enable the items to be withdrawn to the limit of the slides while still being fully operations without any stress of the cables or connectors.
2. Cables that terminate at the equipment racks or lecterns shall have a 10ft whip provided. Attention shall be given to plenum rated installation to make sure proper cable type is used such as riser rated versus plenum rated. The contractor is responsible for verifying the installation requirements. Velcro shall be used to secure cabling at racks. Any in-ceiling cabling shall be suspended above ceiling tiles on J-Hooks or cable tray.

I. Cable Labeling
1. All cables shall be labelled within 2” of the connector with a printed self-lamination label indicating origin and destination. The AV integrator is responsible for supplying and installing proper labels for cablings in a rack.
2. Labeling Example: HDMI input A of a projector should be label ‘INPUT A.’ Output 2 of HDMI 2 should be labeled ‘HDMI 2 Out 3 to PROJ Input A’.
3. Masking tape, insulation tape and handwritten with permanent pen shall not be used for final labels shall not be used.
4. AV drawings shall be supplied by the AV Integrator with cable numbers shown, prior to installation for approval by WTCC ITS AV and AV consultant.

1.03 SYSTEM DESCRIPTION

A. The system description below shall be used in coordination with the provided AV System drawings.

B. SY1: Digital Signage (3 Locations)
1. Each Location shall have a 55” flat panel display. The display shall be wall mounted and protrude less than 4” off the wall. An owner furnished; contractor installed PC shall be mounted behind the flat panel display. The PC shall be run into HDMI Input 1 of the display. If required based on the PC, the AV contractor shall be responsible for providing and cables necessary to proper wire the system.

C. SY2: Advising 160
1. Advising 102 shall have a 55” flat panel display. The display shall be wall mounted and protrude less than 4” off the wall. An owner furnished; contractor installed PC shall be mounted behind the flat panel display. The PC shall be run into HDMI Input 1 of the display. If required based on the PC, the contractor shall be responsible for providing and cables necessary to proper wire the system.

D. SY3: Shared Computer 133

1. The shared computer lab shall have a ceiling mounted projector. The projector shall project a 106” diagonal image onto a mattrite/projectrite surface provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 6 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

E. SY4: Classroom/Computer Lab 134
   1. The classroom/computer lab shall have a ceiling mounted projector. The projector shall project a 119” diagonal image onto a mattrite/projectrite surface provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 6 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

F. SY5: Materials Lab 130
   1. The materials shall have dual ceiling mounted projector. The projectors shall project a 106” diagonal image onto a mattrite/projectrite surface provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections, and 2 HDMI locations located in the rear of the room. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 10 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

G. SY6: Lobby 100E
   1. The presentation space shall have an 85” flat panel display. The display shall be wall mounted. Sources available to the display are an owner furnished, contractor installed PC (includes wireless keyboard and mouse) and 2 HDMI Input locations located in floor boxes. An AV control panel shall be wall mounted next to the flat panel display. The system shall come equipment with a wireless microphone system as well as 2 connections for a wired microphone. Audio will be distributed through 10 ceiling speakers. The wall mounted equipment rack will house all AV equipment. The equipment rack shall be located in shared STOR/SUPT 131a.

H. SY7: CAD Lab #1 205
   1. The CAD lab #1 shall have a ceiling mounted projector. The projector shall project a 133” diagonal image onto a mattrite/projectrite surface provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 8 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

I. SY8: CAD Lab #2 202

1. The CAD lab #2 shall have dual ceiling mounted projector. The projectors shall project a 119” diagonal image onto a mattrite/projectrite surface provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), ceiling mounted, and lectern mounted document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 10 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

J. SY9: Shared Computer Lab 232 & 235 (Qty 2)
1. The shared computer labs shall have a ceiling mounted projector. The projector shall project a 92” diagonal image onto a mattrite/projectrite surface provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 6 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

K. SY10: Large Conf 277
1. The large conference room shall have an 86” interactive display. The display shall have the ability to be height adjustable. The sources available within the room are an owner furnished, contractor installed PC (includes wireless keyboard and mouse), an HDMI and USB-C connections located at the table. The HDMI and USB-C connections will come from within the Extron cable cubby located on the table. The contractor shall be responsible for the cutouts on the table. The contractor shall coordinate location of cutout with architect and owner prior to installation. A webcam located above the display shall be used for video conferencing. Two ceiling microphones shall be used to pick up in room participants on video/audio conference calls. 6 ceiling speakers shall be used to distribute audio within the room. An AV equipment rack located within a credenza shall be located within the corner of the room. The contractor shall coordinate finishes for the credenza with the architect and owner prior to purchase.

L. SY11: 40P Classroom 313
1. The 40P classroom shall have a ceiling mounted projector. A 123” ceiling recessed projection screen shall be provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 8 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection. An auto tracking camera shall be installed in the rear of the room to capture the presenter, either during a conference call or if the class is being recorded. 3 ceiling microphones shall be utilized to capture the professor in the front of the room.

M. SY12: 24P Classroom 312
1. The 24P classroom shall have a ceiling mounted projector. A 113” ceiling recessed projection screen shall be provided by the contractor. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out

shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 6 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection. An auto tracking camera shall be installed in the rear of the room to capture the presenter, either during a conference call or if the class is being recorded. 2 ceiling microphones shall be utilized to capture the professor in the front of the room.

N. SY13: Control Room 341
   1. The control room shall have a ceiling mounted projector. A 109” ceiling recessed projection screen shall be provided by the contractor. Along with the projection screen two 55” ceiling mounted displays shall be utilized for viewers in the rear of the room. Contractor shall provide pricing for ceiling mounted displays as an alternate. Both the projection screen and display shall show the same content. The lectern shall house all AV equipment. The available sources within the room are an owner furnished, contractor installed PC, (included monitor and wireless keyboard and mouse), document camera, 2 HDMI, and USB-C connections. All connections will come from an Extron cable cubby. The cut out for the cable shall be provided by the lectern manufacturer, location of cut out shall be coordinated with WTCC AV ITS. The AV control panel shall be located on the lectern. Audio shall be distributed through 8 ceiling speakers within the room. A 1RU rack panel shall be provided with a Listen Assist connection and Service connection.

O. SY14: Filling/Packing 350A
   1. The filling/packing room shall come equipped with a 65” flat panel display. The display shall be wall mounted. A wall mounted HDMI connection shall be located below the display and feed into HDMI input 1 on the display.

P. SY15: Fermentation 350C
   1. The fermentation room shall come equipped with a two-ceiling mounted 75” flat panel displays. Three wall mounted HDMI connections shall be located in the room. A 7" wall mounted control panel located next to 1 of the HDMI connections. A ceiling enclosure shall house all AV equipment. The displays shall show the same content.

Q. SY16: SM Conf 302
   1. The small conference room shall have a 75” interactive display. The display shall have the ability to be height adjustable. The sources available within the room are an owner furnished, contractor installed PC (includes wireless keyboard and mouse), HDMI, and USB-C connections located at the table. The HDMI and USB-C connection will come from within the Extron cable cubby located on the table. The contractor shall be responsible for the cutouts on the table. The contractor shall coordinate location of cutout with architect and owner prior to installation. A webcam located above the display shall be used for video conferencing. One ceiling microphone shall be used to pick up in room participants on video/audio conference calls. 2 ceiling speakers shall be used to distribute audio within the room. An AV equipment rack located within a credenza shall be located within the corner of the room. The contractor shall coordinate finishes for the credenza with the architect and owner prior to purchase.

R. SY17: Hyflex Classroom Alt
   1. Provide pricing to include a camera, and ceiling microphones to any classroom. An auto tracking camera shall be installed in the rear of the room to capture the presenter, either during a conference call or if the class is being recorded. 4 ceiling microphones shall be utilized to capture all participants within the room. The ceiling speakers shall also be adjusted based on the system drawings.

1.04 BILL OF MATERIALS

A. SY1: Digital Signage (3 Locations)

Model	Manufacturer	Item / Description	Qty
	Display Devices		
TS325TU	Chief	MEDIUM, 25" EXTENSION, SWING ARMS	1

QB55B	Samsung	55INCH/3840X2160/350NIT	1
	Sources		
OFCI PC	OFE	Owner furnished; contractor installed PC	1
	Accessories		
CSPBPTA	Chief	Component Storage Panel TA Backplane	1
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1

B. SY2: Advising 160

Model	Manufacturer	Item / Description	Qty
	Display Devices		
TS325TU	Chief	MEDIUM, 25" EXTENSION, SWING ARMS	1
QB55B	Samsung	55INCH/3840X2160/350NIT	1
	Sources		
OFCI PC	OFE	Owner furnished; contractor installed PC	1
	Accessories		
CSPBPTA	Chief	Component Storage Panel TA Backplane	1
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1

C. SY3: Shared Computer 133

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1
RPAUW	Chief	UNIVERSAL RPA WHITE	1
CMS0203W	Chief	ADJ. PIPE 24" TO 36" WHITE	1
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	1
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	3
	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1

OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Freedom XRS Elite Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	1
97507	Spectrum Industries	3Ru Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

D. SY4: Classroom/Computer Lab 134

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1
RPAUW	Chief	UNIVERSAL RPA WHITE	1
CMS018024W	Chief	ADJ. PIPE 18" TO 24" WHITE	1
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	1

60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	3
	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Freedom XRS Elite Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	1
97507	Spectrum Industries	3Ru Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

E. SY5: Materials Lab 130

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	2
RPAUW	Chief	UNIVERSAL RPA WHITE	2
CMS0203W	Chief	ADJ. PIPE 24" TO 36" WHITE	2

	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	1
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	5
	Video System		
60-1421-13	Extron Electronics	DTP T HWP 4K 231 D DTP Transmitter for HDMI - Decorator-Style Wallplate, White - 230 feet (70 m)	2
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
60-1271-12	Extron Electronics	DTP HDMI 4K 230 Tx HDMI Twisted Pair Transmitter - 230 feet (70 m)	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Freedom XRS Elite Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-	1

		Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	2
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

F. SY6: Presentation Space 100E

Model	Manufacturer	Item / Description	Qty
	Display Devices		
TS525TU	Chief	THIN SWING ARM (LARGE)	1
QE85T	Samsung	QE85T Standalone Display Crystal UHD 3840x2160,300 nit, 16/7	1
	Sources		
OFE	Owner	OWNER FURNISHED; CONTRACTOR INSTALLED PC	1
	Audio System		
60-1852-01	Extron Electronics	XPA U 1004C-70V Four Channel Combo Amp - Two Channels at 8 or 4 ohms - Two Channels at 70V	1
ATND8677A	Audio Technica	Microphone desk stand with Dante network output, support for Dante Domain Manager and Dante AES67 mode, works with any phantom-powered condenser gooseneck microphone with a 3-pin XLRM-type output connector	1
ULXD4D=-G50	Shure	Dual Digital Wireless Receiver with internal power supply, 1/2 Wave Antenna and Rack Mounting Hardware	1
UA834WB	Shure	In-line antenna amplifier for remote mounting. (470-902 MHz)	2
ULXD1=-G50	Shure	Digital Wireless Bodypack Transmitter with Miniature 4-Pin Connector	1
RK183WS	Shure	"Black Snap-Fit Foam Windscreens for MX183, MX184, MX185, BETA 98, WH30, WL183, WL184, WL185 (Contains Four)"	1
ULXD2/K8B	Shure	Handheld Transmitter with KSM8 Microphone (Black)	1
WA371	Shure	Mic Clip for all Handheld Transmitters	1
20130.500.02	K&M	Microphone Stand	1
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer	5
60-1753-01	Extron Electronics	AXI 02 AT Two Output Dante Audio Interface	1
PRO49Q	Audio Technica	Cardioid Condenser Microphone	1
MX183	Shure	Omnidirectional Condenser Lavalier Microphone with 4’ (1.2m) attached cable, Belt-Clip Preamp with XLR, Rotable Tie Clip, Dual Tie Clip, Snap-Fit Windscreen	1
60-1760-02	Extron Electronics	XPA U 1004-70V Four Channel Amp, 100 watts at 70 volts	1

	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1471-12	Extron Electronics	USB Extender Plus T Twisted Pair Extender for USB Peripherals	1
60-1471-13	Extron Electronics	USB Extender Plus R Twisted Pair Extender for USB Peripherals	1
60-1421-13	Extron Electronics	DTP T HWP 4K 231 D DTP Transmitter for HDMI - Decorator-Style Wallplate, White - 230 feet (70 m)	2
60-1271-13	Extron Electronics	DTP HDMI 4K 230 Rx HDMI Twisted Pair Receiver - 230 feet (70 m)	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
60-1563-02	Extron Electronics	TLC Pro 725M 7" Wall Mount TouchLink® Pro Control System - BLACK	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
IQBP-2A	Middle Atlantic	INTL QT 2 BLWR PNL 1SP AN	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
EWR-16-22SD	Middle Atlantic	16SP/22D ECONO WLRKBKDR	1
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1

G. SY7: CAD Lab #1 205

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1
RPAUW	Chief	UNIVERSAL RPA WHITE	1
CMS006009W	Chief	ADJ. PIPE 6" TO 9" WHITE	1
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	2

60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	4
	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Freedom XRS Elite Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	2
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

H. SY8: CAD Lab #2 202

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	2
RPAUW	Chief	UNIVERSAL RPA WHITE	2
CMS006009W	Chief	ADJ. PIPE 6" TO 9" WHITE	2

	Sources		
999-9968-200	Vaddio	DocCAM 20 HDBT OneLINK HDMI System N/A	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
DC-21	Epson	Document Camera	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	2
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	5
	Video System		
60-1583-01	Extron Electronics	DTP CrossPoint 82 4K 8x2 Seamless 4K Scaling Presentation Matrix Switcher - Preamp Output w/o Amplifier and Control Processor	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Freedom XRS Elite Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Left-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Right, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1

95522B	Spectrum Industries	Titan 825 Single Monitor Arm	2
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

I. SY9: Shared Computer Lab 232 & 235 (Qty 2) Equipment shown below is for 1 compete room. All Quantities will need to be doubled as this system includes room 232 & 235.

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1
RPAUW	Chief	UNIVERSAL RPA WHITE	1
CMS009012W	Chief	ADJ. PIPE 9" TO 12" WHITE	1
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	1
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	3
	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2

	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Freedom XRS Elite Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	1
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

J. SY10: Large Conf 277

Model	Manufacturer	Item / Description	Qty
	Display Devices		
484A09	BalanceBox	BalanceBox650 Heavy	1
481A70	BalanceBox	Universal VESA Bracket	1
C8621QT	Dell	86" INTERACTIVE DISPLAY	1
	Sources		
OFE	Owner	OWNER FURNISHED; CONTRACTOR INSTALLED PC	1
	Audio System		
Parle TCM-1A	Biamp Systems	AVB Beamtracking ceiling microphone with PoE+ amplifier, white pendant mount	2
Parle TCM-1EX	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1
C-IC6 White	Biamp Systems	In-Ceiling, Indoor 6.5" Coaxial Loudspeaker, White (priced individually, but sold in pairs)	6
	Video System		
60-1626-52	Extron Electronics	DTP2 T 204 Four Input 4K/60 HDMI Switcher with Integrated DTP2 Transmitter	1
60-1588-52	Extron Electronics	DTP2 R 212 HDMI 4K/60 DTP2 Receiver and Switcher with Audio De-Embedding	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Conference System		
960-001105	Logitech	BRIO 4K Webcam 4K HDR 5x zoom Webcam, 90-78-65° dFOV, Windows Hello Certified, Removable clip, Privacy shade.	1
Devio SCX 400	Biamp Systems	Conference room hub	1

	Cables, Adapters, and Misc. Hardware		
70-1046-02	Extron Electronics	Cable Cubby 700 Cable Cubby 700, Black, No AC	1
60-1697-01	Extron Electronics	AC+USB 224 US (2) AC & (2) USB Outlets w Integrated PS	1
70-090-11	Extron Electronics	Blank Plate - Single Space AAP - Black: Blank Plate	1
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
C3TECHKIT4-SO	Middle Atlantic	C3RACKKIT4RUSLIDEOUT	1
C3-FF32-1	Middle Atlantic	C3 FRAME1 BAY32"HV2	1
C3K1D1HB9A6ZP LBK	Middle Atlantic	C3K1X10X32MHB9A6LBK	1

K. SY11: 40P Classroom 313

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1
RPAUW	Chief	UNIVERSAL RPA WHITE	1
CMS006009W	Chief	ADJ. PIPE 6" TO 9" WHITE	1
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND 2 MONITORS	1
	Audio System		
Parle TCM-1	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1
Parle TCM-1EX	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	2
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer	4
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	2
	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1471-12	Extron Electronics	USB Extender Plus T Twisted Pair Extender for USB Peripherals	1
60-1471-13	Extron Electronics	USB Extender Plus R Twisted Pair Extender for USB Peripherals	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Conference System		
HuddleCamHD SimplTrack2	HuddleCam HD	Second Generation Auto-Tracking | 20X Optical Zoom | IP Streaming, 3G-SDI, DVI-D, USB3.0 | 59° FOV | Control Software only available in English for Windows | US Power Supply | Gray	1

HCM-2-WH	HuddleCamHD	Large Universal Wall Mount for Select Cameras (White)	1
TersiaForte X400	Biamp Systems	TesiraFORTÉ X 400 is a meeting room DSP featuring multiple network and analog audio connection points, with 4 channels of Acoustic Echo Cancellation (AEC) assignable across any digital or analog input. Five 1-Gigabit Ethernet ports are provided, four of which are PoE+ powered, and which support media and control traffic of various types including AVB, Dante and VoIP.	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	1
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Honors Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	2
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

L. SY12: 24P Classroom 312

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1

RPAUW	Chief	UNIVERSAL RPA WHITE	1
CMS006009W	Chief	ADJ. PIPE 6" TO 9" WHITE	1
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND 2 MONITORS	1
	Audio System		
Parle TCM-1	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1
Parle TCM-1EX	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer	3
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	1
Parle TCM-X White	Biamp Systems	AVB Beamtracking™ ceiling microphone, white surface mount	1
	Video System		
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1471-12	Extron Electronics	USB Extender Plus T Twisted Pair Extender for USB Peripherals	1
60-1471-13	Extron Electronics	USB Extender Plus R Twisted Pair Extender for USB Peripherals	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Conference System		
HuddleCamHD SimplTrack2	HuddleCam HD	Second Generation Auto-Tracking | 20X Optical Zoom | IP Streaming, 3G-SDI, DVI-D, USB3.0 | 59° FOV | Control Software only available in English for Windows | US Power Supply | Gray	1
HCM-2-WH	HuddleCamHD	Large Universal Wall Mount for Select Cameras (White)	1
TersiaForte X400	Biamp Systems	TesiraFORTÉ X 400 is a meeting room DSP featuring multiple network and analog audio connection points, with 4 channels of Acoustic Echo Cancellation (AEC) assignable across any digital or analog input. Five 1-Gigabit Ethernet ports are provided, four of which are PoE+ powered, and which support media and control traffic of various types including AVB, Dante and VoIP.	1
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1

	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	1
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Honors Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	2
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

M. SY13: Control Room 341

Model	Manufacturer	Item / Description	Qty
	Display Devices		
V11HA27020	Epson	EPSON PowerLite L530U Projector with WIFI	1
MCM1U	Chief	SINGLE CEILING MOUNT MEDIUM BLACK	1
CMS0406	Chief	ADJ. PIPE 48" TO 72"	1
CMA640	Chief	DEC RING 1.9" ID CMS ADJ INSIDE CLMN	1
RPAUW	Chief (Alternate)	UNIVERSAL RPA WHITE	2
CMS006009W	Chief (Alternate)	ADJ. PIPE 6" TO 9" WHITE	2
QB55B	Samsung (Alternate)	55INCH/3840X2160/350NIT	2
	Sources		
DC-21	Epson	Document Camera	1
OFE	Owner	OWNER FURNISHED, CONTRACTOR INSTALLED PC AND MONITOR	1
	Audio System		
60-850-01	Extron Electronics	XPA 2001-70V One Channel Amp, 200 watts at 70 volts	1
60-1310-03	Extron Electronics	SF 26CT SoundField XD 6.5" Two-Way Ceiling Speaker with 8" Composite Back Can and 70/100 V Transformer, Pair	4

	Video System		
60-1271-13	Extron Electronics	DTP HDMI 4K 230 Rx HDMI Twisted Pair Receiver - 230 feet (70 m)	2
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1437-01	Extron Electronics (Alternate)	HDMI to Four Output DTP Twisted Pair Distribution Amplifier - 230 feet (70 m)	1
	Control System		
60-1562-02	Extron Electronics	TLP Pro 725T 7" Tabletop TouchLink® Pro Touchpanel - Black	1
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
ISOBAR12ULTRA	Tripp Lite	Tripp Lite ISOBAR12ULTRA Rackmount12-Outlet Isobar Surge Suppressor	1
CUSTOM	AVC	1RU RACK PANEL FOR LISTEN ASSIST CONNECTIONS	1
70-212-01	Extron Electronics	MBU 123 Low-Profile Mount Kit for 1/8, 1/4, and 1/2 Rack Width Products	2
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
Honors Lectern	SPECTRUM FURNITURE	Expressions Laminate: Wild Cherry, Choose Your Edgeband Color: Wild Cherry, Metal Finish: Black, Lectern Style: Overbridge Right-Full Panel Custom, Worksurface Power Equipment: None, Overbridge Cutout 1: Extron CC222, Overbridge Cutout 2: Extron TLP Pro 725M, Instruction Orientation: Instructor Left, Rack Cabinet: Rack Cabinet, Flip-Up Shelf: No Flip-up Shelf Needed, Keyboard Tray: Yes Keyboard Tray, Logo Panel Option: No Logo Panel	1
95522B	Spectrum Industries	Titan 825 Single Monitor Arm	1
97507	Spectrum Industries	3RU Rack Mount Cooling Fan	1
60-1927-02	Extron Electronics	Cable Cubby 222 US One US AC Outlet, 12 A Circuit Breaker, and 2 Outlets Under	1

N. SY14: Filling/Packing 351A

Model	Manufacturer	Item / Description	Qty
	Display Devices		

TS325TU	Chief	MEDIUM, 25" EXTENSION, SWING ARMS	1
QB65B	Samsung	65INCH/3840X2160/350NIT	1
	Video System		
CUSTOM	AVC	HDMI FACEPLATE (1 GANG)	1
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1

O. SY15: Fermentation 351C

Model	Manufacturer	Item / Description	Qty
	Display Devices		
QB75B	Samsung	75"3840x2160 4K UHD LED LCD Display, 350 nit 16/7	2
LCM1U	Chief	SINGLE CEILING MOUNT LARGE BLACK	2
CMS0406	Chief	ADJ. PIPE 48" TO 72"	2
CMA640	Chief	DEC RING 1.9" ID CMS ADJ INSIDE CLMN	2
	Video System		
CUSTOM	AVC	HDMI FACEPLATE (1 GANG)	1
60-1271-13	Extron Electronics	DTP HDMI 4K 230 Rx HDMI Twisted Pair Receiver - 230 feet (70 m)	1
60-1615-01	Extron Electronics	IN1808 Standard Model	1
60-1421-13	Extron Electronics	DTP T HWP 4K 231 D DTP Transmitter for HDMI - Decorator-Style Wallplate, White - 230 feet (70 m)	2
	Control System		
60-1911-01	Extron Electronics	IPCP Pro 250 xi IPCP Pro xi Control Processor	1
OFE	Owner	OWNER FURNISHED; CONTACTOR INSTALLED NETWORK SWITCH	1
60-1563-02	Extron Electronics	TLP Pro 725M 7" Wall Mount TouchLink® Pro Touchpanel - Black	1
	Rack Enclosures & Equipment		
CB-224	FSR	2'x2' CB w/ 4 1RU Mounts and 5 internal / 1 external AC Outlet	1
CB-224FAN	FSR	Fan Kit for CB-224	1
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1

P. SY16: SM Conf 302

Model	Manufacturer	Item / Description	Qty

	Display Devices		
C7520QT	Dell	75" INTERACTIVE DISPLAY	1
480A14	BalanceBox	BalanceBox 400 Heavy	1
481A70	BalanceBox	Universal VESA Bracket	1
	Sources		
OFE	Owner	OWNER FURNISHED; CONTRACTOR INSTALLED PC	1
	Audio System		
Parle TCM-1A	Biamp Systems	AVB Beamtracking ceiling microphone with PoE+ amplifier, white pendant mount	1
Parle TCM-1EX	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1
C-IC6 White	Biamp Systems	In-Ceiling, Indoor 6.5" Coaxial Loudspeaker, White (priced individually, but sold in pairs)	2
	Video System		
60-1626-52	Extron Electronics	DTP2 T 204 Four Input 4K/60 HDMI Switcher with Integrated DTP2 Transmitter	1
60-1588-52	Extron Electronics	DTP2 R 212 HDMI 4K/60 DTP2 Receiver and Switcher with Audio De-Embedding	1
60-1883-01	Extron Electronics	USB-C HD 101 USB-C to HDMI Interface	1
	Conference System		
Devio SCX 400	Biamp Systems	Conference room hub	1
960-001105	Logitech	BRIO 4K Webcam 4K HDR 5x zoom Webcam, 90-78-65° dFOV, Windows Hello Certified, Removable clip, Privacy shade.	1
	Cables, Adapters, and Misc. Hardware		
70-1046-02	Extron Electronics	Cable Cubby 700 Cable Cubby 700, Black, No AC	1
60-1697-01	Extron Electronics	AC+USB 224 US (2) AC & (2) USB Outlets w Integrated PS	1
70-090-11	Extron Electronics	Blank Plate - Single Space AAP - Black: Blank Plate	1
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1
	Technical Furniture		
C3TECHKIT4-SO	Middle Atlantic	C3RACKKIT4RUSLIDEOUT	1
C3-FF32-1	Middle Atlantic	C3 FRAME1 BAY32"HV2	1
C3K1D1HB9A6ZP LBK	Middle Atlantic	C3K1X10X32MHB9A6LBK	1

Q. SY17: Hyflex Classroom Alt

Model	Manufacturer	Item / Description	Qty
	Audio System		
Parle TCM-1	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1
Parle TCM-1EX	Biamp Systems	AVB Beamtracking ceiling microphone, white pendant mount	1

	Conference System		
HuddleCamHD SimplTrack2	HuddleCam HD	Second Generation Auto-Tracking | 20X Optical Zoom | IP Streaming, 3G-SDI, DVI-D, USB3.0 | 59° FOV | Control Software only available in English for Windows | US Power Supply | Gray	1
HCM-2-WH	HuddleCamHD	Large Universal Wall Mount for Select Cameras (White)	1
60-1471-12	Extron Electronics	USB Extender Plus T Twisted Pair Extender for USB Peripherals	1
60-1471-13	Extron Electronics	USB Extender Plus R Twisted Pair Extender for USB Peripherals	1
TersiaForte X400	Biamp Systems	TesiraFORTÉ X 400 is a meeting room DSP featuring multiple network and analog audio connection points, with 4 channels of Acoustic Echo Cancellation (AEC) assignable across any digital or analog input. Five 1-Gigabit Ethernet ports are provided, four of which are PoE+ powered, and which support media and control traffic of various types including AVB, Dante and VoIP.	1
Parle TCM-X White	Biamp Systems	AVB Beamtracking™ ceiling microphone, white surface mount	1
	Cables, Adapters, and Misc. Hardware		
Misc. Materials	Allowance	Misc. Hardware, Cables, Connectors, etc.	1

1.05 CABLING

A. The following cables are considered acceptable for WTCC audio-visual installations for in-room use only. Cabling shall be approved by the AV consultant and WTCC prior to installation.
   1. HDMI: HDMI1.4 rated: Extron, Liberty
   2. HDMI Fiber: Hybrid HDMI1.4 rated: Liberty, FSR
   3. Audio: Speaker cable 12-2 through 18-2: West Penn, Belden, Liberty
   4. USB3.0 Hybrid: Thunderbolt: Corning
   5. USB3.0 Hybrid: Active Extension: DigitaLinx
   6. Data: CAT6STP, CAT6UTP, CAT5E UTP: Liberty, West Penn, Belden, CommScope
   7. Audio: 12-2 through 18-2 speaker cabling: West Penn, Belden, Liberty
   8. Audio shielded: 18/2 OAS through 22/2 OAS: West Penn, Belden, Liberty

PART 2 EXECUTION

2.01 PROJECTORS

A. The contractor shall verify all projector and lens combinations with the actual throw distance and lens shift requirements to ensure compatibility prior to ordering.

B. Projectors shall be installed with the vertical center of the lens aligned with the vertical center of the projection screen unless otherwise indicated on the TA series drawings.

C. Projection image adjustments may be made using mechanical lens shift and optical zoom. The use of digital zoom, keystone, and pixel correction is not permitted.

D. Projectors shall be installed and configured to completely fill the projection image surface. Projectors displaying on screens with a black border around the image area shall have the

projector image oversized to leave no unlit portion of the image area. Projectors displaying on edgeless screens shall have no portion of the projection beam overspilling to a surface behind.

E. Mount projectors securely using listed hardware designed and intended for this purpose. If extension columns are utilized with above ceiling infrastructure, route all cabling through the extension column. Dress all cabling with hook and loop fastener.

F. Mount all video receivers or other accessories to be installed with the projector in an above ceiling plenum enclosure, if specified for the project. If not specified, neatly secure to the projector mount and utilize the minimum possible cable length. All service loops for ceiling mounted projectors are to be located above the ceiling or otherwise hidden from view.

2.02 FLAT PANEL DISPLAYS

A. Flat panel display installations shall comply with the Americans with Disabilities Act guidelines for wall obstructions.

B. Flat panel displays shall be mounted using hardware guaranteeing a minimum 5:1 safety factor.

C. Steel Welded Wire Reinforcement:

2.03 RADIO FREQUENCY PRODUCTS

A. Prior to ordering wireless microphone systems, the Contractor shall conduct a radio frequency spectrum survey of the site and provide wireless microphone systems in appropriate frequency bands for the actual RF conditions on site. The Contractor shall provide to the owner a schedule of wireless microphone systems installed, the room in which they are installed, their frequency band, and programmed frequency.

B. Label all wireless microphones with the room and channel number using white text on black background labels.

C. The Contractor shall provide to the owner a schedule of assisted listening systems installed, the room in which they are installed, the programmed frequency, and quantity of receivers provided in each room. If assisted listening system line level outputs are provided in the room for future or pool equipment use, the schedule shall note the location and type of jack.

D. Label all assisted listening receivers with the room number using white text on black background labels.

E. Air Entrainment Admixture: ASTM C 260.

2.04 OTHER

A. The Contractor shall coordinate with the owner’s information technology staff to ensure each device connected to the owner’s enterprise network is connected to a jack with the appropriate network configuration for that device.

B. For all products that are available in multiple color options, the Contractor shall confirm product color with the Owner or Architect prior to ordering.

C. If any specialized cables, adapters, converters, or electronics are required for general maintenance or basic configuration changes to included equipment, the AV contractor shall supply at least one of each type required to the owner during testing and acceptance.

END OF SECTION

SECTION 27 53 13.13 – ANALOG WALL CLOCKS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Analog Wall Clocks

1.03 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. GPS: Global Positioning System, a worldwide system that employs a constellation of satellites in an integrated network to determine geographic location anywhere in the world, and which employs and transmits Universal Coordinated Time.

C. NTP: Network Time Protocol, used for synchronizing clocks on computer networks and devices from either a public server or a separate server on a private local area network.

D. UTC: Universal Coordinated Time

1.04 SUBMITTALS

A. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Product Data: Submit complete catalog data for each component, describing physical characteristics and method of installation. Submit brochure showing available colors, styles, sizes, and finishes of clocks.

C. Samples: Submit one specified system device model(s) for approval. Approved sample(s) shall be tagged and shall be installed in the work at location directed.

D. Manufacturer Instructions: Submit complete installation, set-up and maintenance instructions.

E. Floor plans indicating the location of system transmitter(s), approved by Manufacturer, will be submitted to Owner prior to installation.

F. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment. Furnish the license or a copy of the application for the license to the Owner/End User prior to operating the equipment. The original license must be delivered to the Owner/End User.

1.05 QUALITY ASSURANCE

A. Permits: Operating license for the transmitter from the FCC.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather tight, wet work in spaces is complete and dry, and work above ceilings is complete. Deliver all components to the site in the Manufacturer original packaging.

B. Packaging shall contain Manufacturer name and address, product identification number, and other related information.

C. Store equipment in finished building and in unopened packaging until ready for installation.

PART 2 PRODUCTS

2.01 ANALOG WALL CLOCKS

A. Basis of Design: Primex Model 14155 or approved equal by Lumichron or American Time.

B. Clock shall be Black, 12.5” Diameter Battery Powered, Analog Wall Clock.

C. System shall operate on a 72MHz frequency and shall be capable of transmitting its signal through common building materials throughout the building and ensuring all system devices receive system data updates.

D. System transmitter shall require a FCC license for operation.

E. Manufacturer shall offer system transmitters with a variety of power output levels to provide coverage for a single building or an entire campus.

F. Manufacturer to provide design analysis to determine transmitter size and guaranteed signal coverage.

G. System shall wirelessly synchronize clocks and/or timers, and shall be capable of clock readouts in multiple time zones where desired.

H. System shall provide a master time source that is transmitted wirelessly from the system master transmitter to secondary system devices. The master time source can either from a system supplied GPS Receiver or from an OWNER defined internal or external NTP server that the master transmitter can access via the OWNER'S Local Area Network (LAN). Up to three designated NTP Servers may be specified to ensure continuity of time synchronization. The master time will be synchronized to UTC.

I. Hard wiring of system clocks for data communication shall not be required.

J. System clocks shall automatically adjust for Daylight Saving Time in locations where DST is observed.

K. Each system clock and other components shall use both precise time and synchronized time.

L. Analog Clocks shall be synchronized to within 10 milliseconds 6 times per day when operating clock strikes 2:01 AM, 6:01 AM, 10:01 AM, 2:01 PM, 6:01 PM, and 10:01 PM, and the system shall have an internal oscillator that maintains plus or minus one second per day between synchronization, so that clock accuracy shall not exceed plus or minus 0.2 seconds.

M. System shall include an internal clock reference so that failure to detect the master time source shall not result in the system clocks failing to indicate time. Additionally, system transmitters shall have an internal battery backup of up to eight hours in the event of a power failure so that settings and the correct master time will be instantly recalled upon restoration of power.

N. System shall incorporate a “fail-safe” design so that failure of any component shall not cause failure of the system. Upon restoration of power or repair of failed component, the system shall resume normal operation without the need to reset the system or any component thereof.

O. If a system transmitter stops transmitting valid time signals due to power failure, the system analog clocks will continue to function as accurate quartz clocks until a valid time signal is decoded. If signal transmission is not restored for three consecutive days, a clock's second hand will “two-step” as a visual indicator that the signal has been lost. A system digital clock/timer that has not decoded a valid time signal for a three consecutive days will display a visual indicator by flashing its colons continuously until a valid time signal is received. Should clocks lose both power and signal, the clocks will not function.

P. Clock locations shall be as indicated and clocks shall be fully portable, capable of being relocated at any time.

Q. System shall provide a mobile configurator app (available for both iOS and Android) that allows OWNER to on-board a new transmitter and manage transmitter settings.

R. System transmitters shall be equipped with Bluetooth® low energy wireless technology that allows the devices to send and receive communication to and from the system mobile configurator app.

S. System shall include access to the Manufacturer system cloud-based software that allows OWNER to manage and monitor system transmitters and receive remote support services. Optionally, the system transmitters can be set to stand-alone mode, which does not allow for remote support services. A system that requires stand-alone computer-based system software or server hardware for system management or monitoring does not meet the requirements for this specification.

T. System transmitters shall require connection to OWNER'S existing wired Ethernet network (DHCP or Non-DHCP) to use NTP as its time source and to also send data to and download settings from the system software.

U. System software and mobile configurator app shall allow for over-the-air (OTA) firmware updates to a system transmitters.

V. System software shall log, store, and display all operating diagnostic errors received from a system transmitter.

W. System must operate in accordance with a “Radio Station Authorization”, Form FCC 601 – LM, granted by the Federal Communications Commission (FCC). This license will be issued to and held by the end user.

2.02 SYSTEM SOFTWARE

A. Software interface shall allow the Wake Tech’s system admin user(s) to manage the system components, including: system transmitter settings, reports, alert rules, system-wide user password complexity settings and user session timeout setting, manage system users and grant user access to system data and features.

B. System software shall allow each system user to manage their own system profile, including their log in email address, password, alert notification preferences, and contact settings.

C. System software shall be licensed and delivered via a Software-as-a-Service (SaaS) model.

D. System software shall include and provide all software and transmitter firmware revision updates.

E. Shall not require the installation of on-site system hardware or software, with the exception of the system transmitter devices that transmit data to and download settings from the system software.

F. Shall maintain and store redundant, data backups for up to seven years.

G. Shall allow system users to access system software from a web browser on a mobile or tablet device or computer with an internet connection and does not require the installation of software or other third-party plug-ins or applications.

H. Shall allow OWNER system admin user(s) to grant and control the data and features available to system users.

I. Shall provide a dashboard view that displays the state of system transmitters and a list of system alerts and system notifications.

J. Shall allow each system user to manage their own system profile, including their log in email address, password, alert notification preferences, and contact settings.

K. Shall allow system users to view current and historical data transmitted by system transmitter devices and the settings of system components. The data and settings viewable to a user shall be limited to the role(s) assigned to their system user profile.

L. Shall allow system users to enter comments to transmitter state-change events.

M. Shall allow systems users to customize how data views are displayed within their system user account.

N. Shall allow user-defined reporting; store and present system historical data in the form of system reports. User-defined data shall include the system transmitter devices included in a report, the frequency a report is system generated, and a specific range of data included in a report. System reports shall be displayed in the system software electronically within the

interface and allow a system user to print and download reports. System shall also allow report data to be restricted based on the role(s) assigned to a system user.

O. Shall generate alert notifications to system users 24 hours a day, 365 days a year by user's alert preference. User alert preferences option shall include to receive email, text, or voice notifications.

P. Shall allow system users to acknowledge system alerts within the system software or from a voice alert notification. And system shall record and store the history of all alerting data and system user actions.

Q. All system user software access sessions between the web browser and the system software shall be encrypted by the HTTPS protocol.

R. Network communication of the system transmitter to and from system software shall be secure and encrypted using the Transport Layer Security (TLS) encryption protocol and Secure Hypertext Transfer Protocol (HTTPS) authentication.

PART 3 EXECUTION

3.01 INSTALLATION

A. Clocks and/or Timers shall not be installed until painting and other finish work in each room is complete.

B. Mobile configurator app: installed on a mobile device meeting the app install requirements.

3.02 SYSTEM STARTUP

A. At completion of installation and prior to final acceptance, turn on the equipment; ensure that all equipment is operating properly, and that all system devices and components are functioning.

3.03 WARRANTY

A. Manufacturer shall provide a 5 year limited warranty on system transmitters, clocks, digital timers, timer control switch, and GPS Receiver.

B. All other system components shall have a 1 year limited warranty, including external antennas and components and universal power supply (UPS).

END OF SECTION

SECTION 28 05 00 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.01 SUMMARY

A. The security contractor shall provide a completely functional integrated physical electronic security solution as detailed here and within the project documentation.

B. Provide labor, materials, coordination, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. Access Control System (ACS)
   2. Video Surveillance System (VSS)

C. It is the intent of these specifications to provide a complete workable integrated security system ready for the Client's use as described within the project documentation. Any items not specifically detailed on the drawings or described in the Specifications, but normally required to conform to the intent, are to be considered as part of the Contract.

D. These specifications are equipment and performance specifications. Actual installation shall be as indicated on drawings, specifications and/or contained within the manufacturers written installation instructions. Any discrepancies found between the specification, drawings and manufacturers' installation instructions shall be immediately brought to the attention of engineer/Client in writing at once. Installation and details indicated on the drawings shall govern if they differ from the specifications.

1.02 REFERENCES

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

B. Related Documents and Sections:
   1. Division 01 – General Requirements
   2. Division 08 - Openings
   3. Division 26 – Electrical
   4. Division 27 - Communications

C. The following codes, associations, acts and agencies, as required by law:
   1. American National Standards Institute/Electronic Industries Association/Telecommunication Industries Association (ANSI/EIA/TIA)
   2. Federal Communications Commission (FCC)
   3. National Fire Protection Association (NFPA)
   4. NFPA-70, 2011 (National Electric Code)
   5. National Electrical Safety Code (NESC)
   6. National Electrical Manufacturers Association (NEMA)
   7. Occupational Safety and Health Administration (OSHA)
   8. UL Standard for Safety
   9. International Building Code
   10. International Fire Code
   11. Any additional applicable local codes or amendments

D. When a discrepancy arises between the above-mentioned codes, standards or guidelines and the standards contained in this document, it shall be brought to the attention of the Owner immediately for resolution. The more stringent of the two guidelines shall be implemented.

1.03 ABBREIVIATIONS AND DEFINITIONS

A. CL - Client (Wake Technical Community College)

B. GC - General Contractor

C. EC - Electrical Contractor

D. SC - Security Contractor

E. TC - Telecommunications Contractor
F. FA - Fire Alarm Contractor
G. DH - Door Hardware Contractor

1.04 RESPONSIBILITY MATRIX

SCOPE ITEM	BID PKG	FURNISH	INSTALL	SPEC SHEET
SECURITY INFRASTRUCTURE				
EQUIPMENT RACKS AND PATCH PANELS		TC	TC	27 11 16
PATCH PANELS		TC	TC	27 11 19
COMMUNICATION BACKBONE CABLING		TC	TC	27 13 13
COMMUNICATION HORIZONTAL CABLING		TC	TC	27 15 13
WIRING POWER FOR DOOR ENCLOSURE		EC	EC	26 00 00
DOOR CONTROLLER ENCLOSURE		SC	EC	28 13 00
WIRING DOOR CONTROLLER MODULES IN ENCLOSURE		SC	SC	28 13 00
CONDUITS, BOXES, AND SLEEVES		EC	EC	26 00 00
SECURITY EQUIPMENT				
NETWORK SWITCHES AND UPS UNITS		CL	CL	27 00 00
IP CAMERAS		SC	SC	28 13 00
IP CAMERA PATCH CABLE TO CAMERA		TC	SC	27 15 13
IP CAMERA PATCH CABLE TO SWITCH		TC	SC	27 15 13
ELECTRONIC DOOR HARDWARE		DH	DH	08 00 00
ELECTRONIC DOOR HARDWARE CABLING AND TERMINATION		SC	SC	28 05 13
ELECTRONIC DOOR HARDWARE POWER CONTROLLER		SC	SC	28 13 00
TRANSFER HINGE (POWER/PASS-THROUGH)		DH	DH	08 00 00
PROXIMITY CARD READER		SC	SC	28 13 00
PROXIMITY CARD READER CABLING AND TERMINATION		SC	SC	28 05 13
REQUEST TO EXIT DEVICES		SC	SC	28 13 00
REQUEST TO EXIT DEVICE		SC	SC	28 05 13

CABLING AND TERMINATION				
DOOR CONTACTS		DH	DH	08 00 00
DOOR CONTACT CABLING AND TERMINATION		SC	SC	28 05 13
DOOR CONTROLLER		SC	SC	28 13 00
DOOR CONTROLLER CABLING AND TERMINATION		SC	SC	28 05 13
DOOR CONTROLLER NETWORK CABLING		TC	TC	27 15 13
FIRE ALARM INTERFACE HARDWARE		FA	FA	28 40 00
ACCESS CONTROL TO FIRE ALARM INTERFACE CABLING		SC	SC	28 13 00
SECURITY EQUIPMENT TESTING AND COMMISSIONING		SC	SC	28 00 00
VIDEO SURVEILLANCE SERVERS		SC	SC	28 23 00
VIDEO SURVEILLANCE STORAGE		SC	SC	28 23 00
VIDEO SURVEILLANCE LICENSING		SC	SC	28 23 00
ACCESS CONTROL SERVERS		CL	CL	28 13 00
ACCESS CONTROL LICENSING		SC	SC	28 13 00

1.05 SYSTEM DESCRIPTION

A. The physical electronic security system will be the center point for the receiving of security signals from various security sub-systems. The Security Operations Center and various Security monitoring locations will receive signals from the Access Control System (ACS) and Video Surveillance System (VSS). Authorized personnel, based on level of authority, will have access to this information and provide control of these systems.

B. This contractor shall be responsible for the coordination and providing the interface for all the systems, but also interfacing and coordinating the signals from other systems from Access Control System (ACS), Video Surveillance System (VSS), Emergency Communications System (ECS), Fire Alarm (FA), BMS, and other systems in the future

C. Requirements
   1. Determine hardware, software, and operation requirements to implement a fully functional security system. Owner shall have final approval of all equipment and locations of system.
   2. Install and program all software packages.
   3. Install and configure all hardware and related equipment.
   4. Setup and configure communications between host server and local workstation.
   5. LAN related information shall be provided by owner.
   6. Configure cameras on Server/NVR application and database.
   7. Test systems operation based on a point-by-point inspection.
   8. Perform end-user training.
   9. Participation in system commissioning.

1.06 WORK INCLUDES

A. The Electronic Security Systems contractor shall provide complete full functional systems, including all components and licensing as described within the Project Contact documents.

B. The Electronic Security Systems contractor shall make final power and data connections to all cameras, power supplies, door hardware, etc.

C. The Electronic Security Systems contractor shall install all low voltage cabling, excluding balanced twisted pair network cabling, as required.

D. Network cabling from the local IDF network patch panel to the security device network outlet will be provided by the Telecommunications Contractor. The Electronic Security Systems contractor shall coordinate with the Telecommunications Contractor to insure proper installation. The Electronic Security Systems contractor shall make the final connection to the security device.

E. Conduit or raceway shall be provided by the Electrical Contractor and is required from devices back to the control and/or network point. The Electronic Security Systems contractor shall coordinate with the Electrical Contractor to insure proper installation.

F. The Electronic Security Systems contractor shall supply all equipment enclosures required for security equipment.

G. The Electronic Security Systems contractor shall coordinate all requirements with owner to ensure equipment being supplied will function with existing security devices.

H. The Electronic Security Systems contractor shall coordinate system requirements with computer hardware being supplied will function as intended.

I. The Electronic Security Systems contractor shall coordinate all locations and layouts of security system with owner and/or architect.

J. LAN/WAN network transmission lines shall be provided by owner. Contractor shall be responsible for interfacing network transmission lines with security system.

K. The Electronic Security Systems contractor shall follow ANSI/TIA standards for all cabling requirements. Coordinate cable type and hardware with owner.

1.07 DEFINITIONS

A. Cable Tray: A support mechanism used to route and support telecommunications and other optical fiber cable. Cable trays may be equipped with side walls or barriers to constrain a cable’s horizontal placement or movement.

B. Category 6A: The balanced twisted-pair specifications characterized by, among other requirements, supports frequencies up to 500 megahertz (MHz).

C. Communications Pathways: Conduits, cable trays or other supports with the sole purpose of carrying communications cabling. Communications pathways shall not be used by other low-voltage systems, including but not limited to fire alarm, security systems, and or building automation wiring or air/vacuum tubes.

D. Horizontal Cabling: The cabling between the Telecommunications Room and the Work Area that carries voice, data and/or video signals.

E. Intermediate Distribution Frame (IDF): An enclosed space designed for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the Backbone and Horizontal Systems. Also frequently referred to as TR.

F. Plenum-rated: Listed by the Underwriters Laboratory as being suitable for installation into a plenum space. Communications cabling routed through plenum-rated space shall be plenum-rated and identified as Type CMP.

G. Telecommunications Room (TR): An enclosed space designed for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the Backbone and Horizontal Systems. Also frequently referred to as IDF (legacy term).

1.08 ABBREVIATIONS AND ACRONYMS

A. ADA - Americans with Disabilities Act
B. AHJ - Authority Having Jurisdiction
C. ANSI - American National Standards Institute
D. AWG - American Wire Gauge
E. BICSI - Building Industry Consulting Service International
F. BPS - Bits per Second
G. CATV - Community Antenna Television (Cable Television)
H. CCTV - Closed Circuit Television
I. CMP - Communications Plenum Cable
J. CPU - Central Processing Unit
K. EIA - Electronic Industries Association
L. FCC - Federal Communications Commission
M. IEEE - Institute of Electrical and Electronics Engineers
N. IPS - Images per Second
O. IT - Information Technology
P. LAN - Local Area Network
Q. NEC - National Electrical Code, NFPA 70
R. NESC - National Electric Safety Code
S. PoE - Power-over-Ethernet
T. RAID - Redundant Array of Independent Disks
U. REX - Request to Exit
V. SCS - Security Control System
W. SDRAM - Synchronized Dynamic Random-Access Memory
X. UL - Underwriters Laboratory
Y. UTP - Unshielded Twisted Pair
Z. VLAN - Virtual LAN
AA. WAN - Wide Area Network

1.09 SUBMITTALS

A. Refer to Division 1 and the General Provisions of the Contract for exact submittal procedures.
B. Provide a resume of qualifications consisting of a list of three recently completed projects of similar type and size with contact names, telephone numbers and email address for each. Jobs must be representative of the work your prosed team has completed.
C. Provide resumes of experience for the Project Manager, Lead Engineer, Lead Field Technician, who will be assigned to this project. Provide electronic copies of required certifications for proposed project team.
D. Work shall not proceed without the Owner and Technology Consultant approval of all submitted items.
E. Shop drawings shall be submitted in advance of construction to cause no delay in other Contractors' work. Shop drawings shall be submitted at such time to allow the Engineer reasonable time to review shop drawings to make necessary corrections.
F. It will be assumed that the Contractor has examined the shop drawings and equipment brochures prior to submission and that materials and equipment depicted will readily fit into the

construction. Contractor shall also review all completed work related to materials or equipment depicted to ensure that it has been properly installed.

G. No materials or equipment subject to prior review by the Engineer shall be fabricated or installed by the Contractor, without such review and approval. The Engineer's review of such drawings and brochures shall not relieve the Contractor of responsibility for deviations from the requirements of the drawings and specifications unless they have notified the Engineer in writing.

H. The Division 28 Contractor shall provide for review, without exception prior to material acquisition and installation, multiple copies of the following items, quantity as required by the General Contractor or Construction Manager, as applicable. Specific requirements shall be listed and described within each Division 28 section. Failure to submit required items shall disqualify the bidder.
   1. Product Data Sheets (Catalog Cuts)
   2. Cabling Diagrams
   3. System Schematics
   4. Specification Sheets for Test Equipment
   5. Bill of Materials
   6. Contracting Firm Qualifications and Certifications
   7. Installation Team Qualifications by Individual
   8. Current Manufacturer Certifications

I. The Division 28 Contractor shall provide Coordination Drawings for review, without exception prior to material acquisition and installation for approval to proceed. Coordination Drawings shall consist of floor plans and building sections, drawn to scale. Include Security System Wiring Diagrams and relationships between components.

J. Provide throughout installation:
   1. Product samples, if requested by the Architect, Technology Consultant, General Contractor, or Construction Manager.
   2. Periodic field quality control reports.
   3. Periodic cable test reports.

K. Provide prior to completion:
   1. Actual samples of the component labeling scheme to be applied to cabling components, to be approved by the Architect, Technology Consultant, General Contractor, or Construction Manager.
   2. Draft cable administration drawings, as requested to assist the Owner in the planning process. Drawings will be requested prior to final documentation and as Xerox reproductions of handwritten field copies.

L. Provide at completion of each construction/testing phase or area, as defined by the General Contractor or Construction Manager:
   1. Cable test and certification reports; summary hard copy or full test results on compact disc when requested by the General Contractor or Construction Manager, the Owner's Networking & Telecommunications, or the Technology Consultant. Reports shall be submitted to the requesting party within thirty (30) working days of completion for each phase.
   2. One (1) full size set of final drawings of the actual installation for the Division 28 systems. Drawings shall be given as E size originals and on disc in AutoCAD format.

M. Provide after the installation is complete
   1. One (1) full size set of record drawings of the actual installation for the Division 28 systems. Drawings shall be given as E size originals and on disc in AutoCAD format.

N. Provide after the installation is complete and two (2) weeks before final acceptance, three (3) bound sets of O&M (Operating and Maintenance) Manuals formatted as defined by Division 1 and within Section 28 00 00. In addition, each copy of the O&M Manual shall include, at minimum, items listed as follows:

1. One (1) copy of each approved submittal.
2. Cable test and certification reports; summary hard copy and full test results on disc.
   a. All test data, including documentation of failed tests, the corrective procedures performed, and the results of re-tests are to be documented and submitted in both hard copy and electronically in ASCII format.
   b. Handwritten test reports shall not be accepted.
   c. All actions required to correct failed tests shall be documented to include the cable identifier, tests that were failed, and actions performed to correct the problem.
3. Instruction manuals including equipment and cable schedules, operating instructions, and manufacturer's instructions.
4. Manufacturer Warranty Certificate.
5. Warranty contacts including but not limited to names, telephone numbers (office and mobile).

1.10 QUALITY ASSURANCE

A. Comply with all local, state, and federal codes.

B. All materials furnished shall be new, unused, clean, and free from damage, defects, or corrosion.

C. Equipment and materials of the same type shall be a product of the same manufacturer throughout unless specifically exempted in advance.

D. The Contractor shall accept complete responsibility for installation, certification, and support of cabling system. Contractor must show proof the vendor has the certifying manufacturer’s support on all these issues with shop drawing submittals.

E. Only installers trained and certified by the proposed manufacturer shall be allowed to install products. Installers must possess the highest level of certification available by the manufacturer for the specific copper cabling solution being installed.

F. The Contractor may provide proof of registration/certification of planned installers in bid documents. If not included in the bid documents, the Contractor shall provide a narrative on the levels of registration/certification of their installers within the bid documents. The Contractor shall provide proof of registration/certification for the final list of installers prior to the start of work.

G. The Owner’s Facilities Management and Networking & Telecommunications reserve the right to reject any unregistered or uncertified installers performing work for which they are not registered/certified. The Contractor shall be responsible for any loss of work, delays in schedules, or extra cost because of the use of unregistered/uncertified workers. Additional effort on the part of the Contractor to maintain the installation schedule because of the above-mentioned loss time shall be the Contractor’s responsibility and at the Contractor’s additional expense.

H. The Contractor shall provide to the Owner’s Campus Facilities Management and Networking & Telecommunications the above required documentation for any worker on this project brought in after the submittal of initial documentation on installers. Owner may periodically check installer identification and registrations/certifications during the installation.

1.11 WARRANTY

A. Warrant work against faulty material or workmanship in accordance with Division 1 requirements. If the Project is occupied or the systems placed into operation in several phases, then the warranty of each system or piece of equipment shall begin on the date each system or piece of equipment was placed into satisfactory operation and accepted as such, in writing, by the Owner. The use of building equipment for temporary service, and/or through testing and commissioning of such equipment, does not constitute the beginning of the warranty.

B. Shall submit, in the bid documents, any additional contractor-specific warranties or guarantees to be offered on the project.

C. Shall supply all necessary documentation needed to process and record the warranty(s) and to verify the installation solution.

D. Manufacturer's Warranty
   1. Equipment and materials required for installation under these standards shall be the current model and new (less than one (1) year from date of manufacture), unused and without blemish or defect, and are to be guaranteed to be free from defect for a minimum of one (1) year from the date of project's substantial completion.
   2. When a defect or problem is observed within the first year after substantial completion, the Owner will notify the governing subcontractor through the proper channels. The appropriate subcontractor then will have 48 hours to fix the defect or furnish and install a replacement part/system, all at no cost to the project or the Owner.

E. Manufacturer's Extended Warranty
   1. All manufacturer extended product warranties shall be afforded to The Owner. A copy of certification by the manufacturer for all products listed in this specification is to be provided.
   2. Prior to commencement of the work, the successful bidder shall contact an authorized manufacturer's representative to inform them that this job is being registered under the warranty program.
   3. Upon completion of the work, coordinate with the manufacturer the issuance of a full warranty on the entire security system. The Electronic Security Systems contractor at its sole expense will correct any deficiencies determined by the manufacturer.

1.12 OPERATION AND MAINTENANCE MANUALS

A. Provide Operations and Maintenance Manuals in accordance with Division 1 requirements.

B. Provide copies of all required test reports.

C. Provide complete warranty certificates for system and equipment.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Insofar as possible, deliver items in the manufacturer's original unopened packaging. Where this is not practical, cover items with protective materials to keep them from being damaged. Use care in loading, transporting, unloading, and storage to keep items from being damaged.

B. Store items in a clean dry place and protect from damage. Evidence of damage from water or other contaminants will be cause for rejection.

1.14 RECORD DRAWINGS

A. Comply with Division 1 requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Equipment and materials furnished shall be listed by UL or other nationally accredited testing laboratory where available. When listing is not available for a piece of equipment, it shall be submitted in accordance with Drawings and Specifications and shall be approved by the authorities having jurisdiction

B. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are available.

C. When more than one unit of the same class of equipment or material is required, such units shall be the products of a single manufacturer and part number.

D. All products and materials shall be new and unused prior to their installation as part of this project. Refurbished items are not allowed.

E. Alternates may be proposed but shall meet or exceed specifications for the items listed. Acceptance shall be at the sole discretion of the owner.

PART 3 EXECUTION

3.01 GENERAL

A. Contractor shall coordinate with all other trades prior to installation. Meeting with the Electrical and General Contractors to identify pathways and infrastructure space requirements.

B. The Owner shall not be responsible for delays in work because of shutdowns due to unsafe working practices by Contractors. Delays enforced by the Safety Office caused by unforeseen environmental conditions in the work area may be out of Contractor's control. Contractors shall contact the Owner's primary project manager immediately if delays are incurred for safety reasons.

C. It shall be the responsibility of the Contractor to secure any parking permits prior to the first day of work on-site.

D. Work outside of normal operating hours and days shall be coordinated with the Owner's Facilities Management.

3.02 FEES AND PERMITS

A. Obtain and pay for all necessary permits and inspection fees required for this installation.

3.03 DIMENSIONS AND DEFINITE LOCATIONS

A. The Project Drawings depicting work show approximate locations. The exact location of equipment and devices shall be established in the field in accordance with instructions from the owner. Consideration shall be given to construction features, equipment of other trades, and requirements of the equipment proper

B. The Contractor shall refer to shop drawings and submittal drawings for equipment requiring electrical connections to verify rough-in and connection locations.

C. Unless specifically stated to the contrary, no drawings by scale shall be used as a dimension to work by. Dimensions noted on the drawings are subject, in each case, to measurements of adjacent or previously completed work and all such measurements necessary shall be taken before undertaking any work dependent upon them.

3.04 PROGRESSIVE AND FINAL CLEANING OF PROJECT SITE

A. During construction, and prior to the Owners acceptance of the building, remove from the premises and dispose of packing material and debris cause by communications work.

B. Remove dust and debris from interior and exterior of Electronic Security Systems equipment. Clean accessible current carrying equipment prior to being energized.

C. Contractor shall clean work areas each day and remove debris properly and legally from the Owner's property. Where communications equipment and related materials are installed or stored for use in the project shall be neatly stacked and remain free of debris, cable scraps and accumulated dust from the floor and surfaces of installed communication equipment, and materials. All exits and paths shall be cleaned to prevent dirt from being tracked throughout the facility.

D. Upon completion of the work, remove excess debris, materials, equipment, tools, and similar items. Leave the premises clean, neat, and orderly.

3.05 INSTALLATION

A. General

B. Cabling Installation

1. Where cables are supported from building structure, they shall be adequately supported such that the cable will not be damaged by normal building use.
2. Cables shall not be installed or routed in any manner that violates the manufacturer's specifications. Manufacturer's minimum bend radius for static (post installation) cables is 10 times the cable diameter. Manufacturer's minimum bend radius for cables under strain (pulling tension) is 20 times the cable diameter.

3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Install a 5-foot-long service loop on each end of cable. Coil service loop at work area end, maintaining appropriate bend radii. Secure service loop to conduit stub or j-hook above ceiling with Velcro.
5. Unless otherwise specified, terminate cables in accordance with ANSI/TIA/EIA-568-A, Commercial Building Telecommunications Cabling Standard, observing the industry standards for terminating color- coded cables for premises and campus environments.
6. Do not install damaged or defective cable. Installation of damaged cable will not be accepted. Unless otherwise allowed by the Owner, damaged cable shall be removed, and new cable installed at the expense of the Contractor. Damage includes physical damage to the cable and damage that may affect performance. THE OWNER WILL NOT ACCEPT CABLE OF ANY TYPE UNTIL AFTER IT IS INSTALLED AND PASSES A PHYSICAL INSPECTION AND ALL PERFORMANCE TESTS.
7. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
8. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports ideally 48 inches but not more than 60 inches apart.
9. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
10. Cables shall not be tied or supported by pipes, ducts, ceiling support wires or other building components which are not part of the communications pathway system.
11. Separation guidelines for routing pathways from power lines and equipment:

Separation of Telecommunications Pathways from Power Lines			
Minimum Separation Distance			
Condition	<2KV	2-5KV	>5KV
Unshielded power lines or electrical equipment in proximity to open or non-metal raceways.	5 inches	12 inches	24 inches
Unshielded power lines in proximity to a grounded metal raceway.	2.5 inches	6 inches	12 inches
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to a grounded metal raceway.	N/A	3 inches	6 inches

3.06 CUTTING AND PATCHING

A. Comply with Division 1 requirements.

B. Repair or replace routine damage caused by cutting in performance of Work under this Division.

C. Correct unnecessary damage caused due to installation of electrical Work, brought about through carelessness or lack of coordination.

D. Holes cut through floor slabs shall be core drilled with drill designed for this purpose. All openings, sleeves, and holes in slabs between floors shall be properly sealed, fire proofed and waterproofed.

E. Holes cut through walls shall be drilled or cut with tools designed for the purpose. All openings, sleeves and holes in walls that extend to underside of floor above shall be properly sealed and fire proofed.

F. Repairs shall be performed with materials which match existing materials and be installed in accordance with appropriate sections of these Specifications.

G. Contractor shall not be permitted to cut or modify any structural members without the written permission of the Architect.

3.07 FIRESTOPPING

A. Comply with ANSI/TIA-569-C, Annex A, “Fire-stopping.”

B. Comply with BICSI TDMM, Chapter 8 “Fire-stopping.”

3.08 TESTING

A. Cable Testing
   1. New cable pairs shall be end-to-end tested as follows.
      a. DC loop resistance
      b. Wire map
      c. Continuity to remote end
      d. Shorts between two or more conductors
      e. Crossed pairs
      f. Reversed pairs
      g. Split pairs
   2. All balanced twisted-pair field testers shall be factory calibrated each calendar year by the field test equipment manufacturer as stipulated in the manuals provided with the field test unit. The calibration certificate shall be provided for review prior to the start of testing. Autotest settings, provided in the field tester for testing the installed cabling, shall be set to the manufacturer default parameters for the type and characteristics of the cable to be tested.
   3. Tests shall be performed with connectors and termination completed and in-place.
   4. Any cable or component not satisfactorily passing the tests as described or failing to meet quality installation standards as described in this specification, shall be repaired, and/or replaced at the Contractor's expense.
   5. The Contractor shall prepare complete cable test reports for all installed cables for review and approval by the Owner prior to acceptance of the cabling system.

B. Final Acceptance Testing
   1. After testing reports, as-built drawings, and required manuals have been submitted for review, the Contractor shall coordinate a date for Final Acceptance Testing.
   2. Testing and acceptance of this system will take place in the presence of the owner.
   3. Acceptance of the system shall require a demonstration of all system components to evaluate their performance and reliability. Prior to this test the system must have been online for a period of sixty (60) days, with an uptime of no less than 99%. Should a major equipment failure occur, the Contractor shall replace the defective component and continue the testing period. Any items discovered during final inspection which require the contractor’s attention, shall be promptly addressed. These items will then be re-inspected by the owner for approval.
   4. Upon the completion of acceptable Final Acceptance Testing the Contractor shall submit all finalized project documentation and associated electronic media. Upon approval from the owner, the owner will issue a Letter of Completion to the Contractor indicating the date of such completion. This notice will serve as Client acceptance of this system.

END OF SECTION

SECTION 28 05 13 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the finishing, installation, connection, testing and certification the conductors and cables required for a fully functional for electronic safety and security (ESS) system.

1.02 RELATED WORK

A. Section 01 00 00 - GENERAL REQUIREMENTS. For General Requirements.

B. Section 07 84 00 - FIRESTOPPING. Requirements for firestopping application and use.

C. Section 28 05 00 – COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY. Requirements for general requirements that are common to more than one section in Division 28.

D. Section 31 20 00 - EARTH MOVING. For excavation and backfill for cables that are installed in conduit.

1.03 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. EMI: Electromagnetic interference.

C. IDC: Insulation displacement connector.

D. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

F. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

G. RCDD: Registered Communications Distribution Designer.

H. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.

I. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

J. UTP: Unshielded twisted pair.

1.04 SUBMITTALS

A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:

1. Manufacturer's Literature and Data: Showing each cable type and rating.
2. Certificates: Two weeks prior to final inspection, deliver to the Resident Engineer/COTR four copies of the certification that the material is in accordance with the drawings and specifications and diagrams for cable management system.
3. Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
    a. Vertical and horizontal offsets and transitions.
    b. Clearances for access above and to side of cable trays.
    c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
    d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

e. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.

4. Wiring Diagrams. Show typical wiring schematics including the following:
   a. Workstation outlets, jacks, and jack assemblies.
   b. Patch cords.
   c. Patch panels.

1.05 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by the basic designation only.

B. American Society of Testing Material (ASTM):
   1. Standard Specification for Vinyl Chloride Plastic Pressure Sensitive Electrical Insulating Tape

C. Federal Specifications (Fed. Spec.):
   1. Cable and Wire, Electrical (Power, Fixed Installation)

D. National Fire Protection Association (NFPA):
   1. National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):
   1. Thermoset-Insulated Wires and Cables
   2. Thermoplastic-Insulated Wires and Cables
   3. Electrical Grounding and Bonding Equipment
   4. Wire Connectors and Soldering Lugs for Use with Copper Conductors
   5. Splicing Wire Connectors
   6. Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations
   7. Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
   8. Thermoplastic-Insulated Underground Feeder and Branch Circuit Cable
   9. Fittings for Cable and Conduit
   10. Fire Tests of Through-Penetration Fire Stops//

1.06 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test optical fiber cable to determine the continuity of the strand end to end. Use [optical-fiber flashlight] [or] [optical loss test set] .
   2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
   3. Test each pair of UTP cable for open and short circuits.

1.07 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install any cable and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.01 GENERAL

A. Support of Open Cabling: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with cable tie slots for fastening cable ties to brackets.
   2. Lacing bars and spools.

3. Straps and other devices.

B. Conduit and Boxes:
1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.02 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm).

B. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry"

2.03 UTP CABLE

A. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.
1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2 Category 6a.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
a. Communications, General Purpose: Type CM and CMG .
b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
c. Communications, Riser Rated: Type CMR, complying with UL 1666.
d. Communications, Limited Purpose: Type CMX.
e. Multipurpose: Type MP.
f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
g. Multipurpose, Riser Rated: Type MPP, complying with UL 1666.

2.04 UTP CABLE HARDWARE

A. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.

B. Connecting Blocks:110-style for Category 6. Provide blocks for the number of cables terminated on the block, plus 25% spare. Integral with connector bodies, including plugs and jacks where indicated.

2.05 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM.
1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.06 LOW-VOLTAGE CABLE

A. Plenum rated Access Control Composite Cable
1. Belden 638AFS
a. Element 1 - Card Reader
1) 3 pair, No. 18AWG, stranded
2) PVC Insulation
3) Shielded
4) PVC jacket

5) Flame Resistance: NFPA 262, Flame Test.

b. Element 2 - Door Contact
   1) 2 conductor. No. 18AWG stranded
   2) PVC Insulation
   3) Shielded
   4) PVC jacket
   5) Flame Resistance: NFPA 262, Flame Test.
c. Element 3 - Request to exit
   1) 4 conductor, No. 18 AWG
   2) PVC Insulation
   3) Shielded
   4) PVC jacket
   5) Flame Resistance: NFPA 262, Flame Test.
d. Element 4 - Lock Power
   1) 4 conductor, No. 16 AWG
   2) PVC Insulation
   3) Shielded
   4) PVC jacket
   5) Flame Resistance: NFPA 262, Flame Test.

2. Approved Equal

B. Proximity Card Reader Cable
   1. 6 conductor, No. 18 AWG, stranded or 3 pair, No. 18 AWG, stranded
   2. PVC Insulation
   3. Shielded
   4. PVC Jacket
   5. Flame Resistance: Comply with UL 1581

C. Plenum-Rated Proximity Card Reader Cable
   1. 6 conductor, No. 18 AWG, Stranded or 3 pair, No. 18 AWG stranded
   2. PVC Insulation
   3. Shielded
   4. PVC Jacket
   5. Flame Resistance: Comply with NFPA 262

D. Door Contact Cable
   1. 2 conductor No. 22 AWG, Stranded
   2. PVC Insulation
   3. Shielded
   4. PVC Jacket
   5. Flame Resistance: Comply with UL 1581

E. Plenum Rated Door Contact Cable
   1. 2 conductor No. 22 AWG, Stranded
   2. PVC Insulation
   3. Shielded
   4. PVC Jacket
   5. Flame Resistance: Comply with NFPA 262

F. Lock Power Cable
   1. 4 conductor No. 16 AWG, Stranded
   2. PVC Insulation
   3. Shielded
   4. PVC Jacket
   5. Flame Resistance: Comply with UL 1581

G. Plenum Rated Lock Power Cable

1. 4 conductor No. 16 AWG Stranded
2. PVC Insulation
3. Shileded
4. PVC Jacket
5. Flame Resistance: Comply with NFPA 262

H. Request to Exit Cable
1. 4 conductor No. 22 AWG Stranded
2. PVC insulation
3. Shielded
4. PVC Jacket
5. Flame Resistance: Comply with UL 1581

I. Plenum Rated Request to Exit Cable
1. 4 conductor No. 22 AWG Stranded
2. PVC insulation
3. Sheilded
4. PVC Jacket
5. Flame Resistance: Comply with NFPA 262

2.07 IDENTIFICATION PRODUCTS

A. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.08 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

F. Cable will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

2.09 WIRE LUBRICATING COMPOUND

A. Suitable for the wire insulation and conduit it is used with, and shall not harden or become adhesive.

B. Shall not be used on wire for isolated type electrical power systems.

2.10 FIREPROOFING TAPE

A. The tape shall consist of a flexible, conformable fabric of organic composition coated one side with flame-retardant elastomer.

B. The tape shall be self-extinguishing and shall not support combustion. It shall be arc-proof and fireproof.

C. The tape shall not deteriorate when subjected to water, gases, salt water, sewage, or fungus and be resistant to sunlight and ultraviolet light.

D. The finished application shall withstand a 200-ampere arc for not less than 30 seconds.

E. Securing tape: Glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (3/4 inch) wide.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   1. Comply with TIA/EIA-568-B.1.
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Terminate all conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
   5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
   7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
   9. Pulling Cable:
      a. Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
      b. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables.
      c. Use ropes made of nonmetallic material for pulling feeders.
      d. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors, as approved by the Resident Engineer/COTR.
      e. Pull in multiple cables together in a single conduit.

C. Splice cables and wires where necessary only in outlet boxes, junction boxes, or pull boxes.
   1. Splices and terminations shall be mechanically and electrically secure.
   2. Where the Government determines that unsatisfactory splices or terminations have been installed, remove the devices and install approved devices at no additional cost to the Government.

D. Seal cable and wire entering a building from underground, between the wire and conduit where the cable exits the conduit, with a non-hardening approved compound.

E. Unless otherwise specified in other sections install wiring and connect to equipment/devices to perform the required functions as shown and specified.

F. Except where otherwise required, install a separate power supply circuit for each system so that malfunctions in any system will not affect other systems.

G. Where separate power supply circuits are not shown, connect the systems to the nearest panel boards of suitable voltages, which are intended to supply such systems and have suitable spare circuit breakers or space for installation.

H. Install a red warning indicator on the handle of the branch circuit breaker for the power supply circuit for each system to prevent accidental de-energizing of the systems.

I. System voltages shall be 120 volts or lower where shown on the drawings or as required by the NEC.

J. UTP Cable Installation:
   1. Comply with TIA/EIA-568-B.2.
   2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

K. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

L. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than [60 inches (1525 mm)] apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

M. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable [72 inches (1830 mm)] long shall be neatly coiled not less than [12 inches (300 mm)] in diameter below each feed point.

N. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.02 CONTROL CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:
1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.03 CONNECTIONS

A. Comply with requirements in Division 28 13 00 Section, ACCESS CONTROL SYSTEMS for connecting, terminating, and identifying wires and cables.

B. Comply with requirements in Division 28 23 00 Section VIDEO SURVEILLANCE SYSTEMS for connecting, terminating, and identifying wires and cables.

3.04 FIRESTOPPING

A. Comply with requirements in Division 07 Section "PENETRATION FIRESTOPPING."

B. Comply with TIA/EIA-569-A, "Firestopping" Annex A.

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.05 GROUNDING

A. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Division 28 Section "GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY."

3.06 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A.

B. Install a permanent wire marker on each wire at each termination.

C. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.

D. Wire markers shall retain their markings after cleaning.

E. In each handhole, install embossed brass tags to identify the system served and function.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   4. Optical Fiber Cable Tests:
      a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Link End-to-End Attenuation Tests:
         1) Multimode Link Measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
         2) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
   5. Coaxial Cable Tests: Comply with requirements in Division 27 Section "Master Antenna Television System."

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.08 EXISITNG WIRING

A. Unless specifically indicated on the plans, existing wiring shall not be reused for the new installation. Only wiring that conforms to the specifications and applicable codes may be reused. If existing wiring does not meet these requirements, existing wiring may not be reused and new wires shall be installed.

END OF SECTION

SECTION 28 13 00 - ACCESS CONTROL SYSTEM

PART 1 — GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The access control system shall be manufactured by Software House and compatible with the existing campus wide CCure 9000 . It shall be connected to the existing access control system via a network connection on the existing Wake Tech infrastructure VLAN. The access control system shall be connected to a dedicated normal emergency power circuit, and battery backup power shall be provided.

B. Provide labor, materials, coordination, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. CCure 9000 management software and associated licensing required for a fully functional solution.
   2. Door Controller Boards
   3. Door Controller Cabinets
   4. Card Readers
   5. Door Contacts
   6. Request to Exit Devices
   7. Card Credentials (cards, fobs, etc.)

C. Where applicable, installations must include a relay from the fire alarm system located at each access controller to release required doors upon activation of the fire alarm system. The fire alarm relay to be provided and installed by fire protection contractor. The access control interface to the fire alarm relay is to be wired by Contractor and terminated in the controller by the fire protection contractor. Contractor to provide a data outlet for connection of the access control system to the CCure 9000 server.

D. It is the intent of these specifications to provide a complete workable integrated security system ready for the Client's use as described within the project documentation. Any items not specifically detailed on the drawings or described in the Specifications, but normally required to conform to the intent, are to be considered part of the contract.

E. These specifications are equipment and performance specifications. Actual installation shall be as indicated on drawings, specifications and/or contained within the manufacturers written installation instructions. Any discrepancies found between the specification, drawings, and manufacturers' installation instructions shall be immediately brought to the attention of the engineer/client in writing at once. Installation and details indicated on the drawings shall govern if they differ from the specifications.

1.03 REFERENCES

A. Design and operation of the system shall conform to the following referenced codes, regulations, and standards as applicable:
   1. National Electrical Code (NEC).
   2. UL 294 and UL 1076 as required where applicable.
      a. The system shall be listed by Underwriters Laboratories for UL 294 Access Control Systems, and UL 1076 Proprietary Burglar Alarm systems. PC's and all control panels furnished on the job shall carry the UL 294 and UL 1076 labels as required. Bidders shall provide copies of their UL listing cards or other proof of compliance.
   3. Applicable Federal, State, and Local laws, regulations, and codes.

B. Owner Supplied Specifications
   1. Wake Technical Community College Electronic Security System Design Guideline

C. When a discrepancy arises between the above-mentioned codes, standards or guidelines and the standards contained in this document, it shall be brought to the attention of the Owner immediately for resolution. The more stringent of the two guidelines shall be implemented.

PART 2 – PRODUCTS

2.01 PRODUCT - GENERAL

A. Manufacturers:
   1. Software House
      a. Door Controllers
         1) iStar Ultra G2 Panel
         2) iStar Ultra G2 SE Panel
         3) iStar Ultra Panel
         4) iStar Ultra SE Panel
      b. Modules
         1) I8 Input Modules
         2) I8-CSI Input Modules
         3) R8 Output Modules
         4) RM-4 Reader Module
         5) PSX-D8P PSX Power Solutions Eight Output Distribution Board, PTC
         6) PSX-C8P PSX Power Solutions Eight Lock Module, PTC
         7) PSX-M8P PSX Power Solutions Eight Monitored Lock Module, PTC
      c. Card Readers
         1) Schalge MT 11-485
            (a) Contractor shall provide (1) one spare card reader.
         2) Schalge MT 15-485
            (a) Contractor shall provide (1) one spare card reader.
      d. Alternate Card Reader
         1) HID R15
         2) HID R40
      e. Power Supplies
         1) CC9000-LPOWER CCure 9000 Integration Option with Life Safety Power NetLink Integration with PSX NL2 and NL4 modules
         2) PSX-ISU-E2 PSX Wall Mount with Dual Voltage, 120VAC
         3) AS0063-00 apS with Battery, 120VAC
   2. Bosch
      a. DS160i - Request to Exit PIR Motion Sensor

B. Others:
   1. Door Contacts
      a. Vary depending on installation requirements, typical ¾” recessed in most cases
   2. Card Credentials
      a. MIFARE Smart Card with Mag Stripe
         1) Must check with Wake Tech on start number and facility code before purchasing
   3. Enclosures
      a. NEMA 1 - 12”x12”x4” – For Network Outlet, Fire Alarm Relay, Duplex Power Receptacle
      b. NEMA 1 - 6"x6"x3" - For Access Control Junction Box above each door.
   4. Uninterruptible Power Supply (UPS)
      a. Eaton
      b. APC (American Power Conversion)
   5. Push Button Exit Devices
      a. 1-1/2" green mushroom button, two LEDs, single gang.
         1) Switch Mounted on single gang wall plate with 430 stainless steel finish

2) One N/O and N/C contact
3) Contacts rated 10A at 35 VDC or 120 VAC
4) Switch connection via screw terminals
5) Switch depth behind plate: 2"
6) LEDs operates on 12 or 24 VAC/VDC, independently wired

b. 1-1/2" green mushroom button, narrow style
1) Switch mounted on narrow stile wall plate with 302 stainless steel finish
2) One N/O and N/C contact
3) Contacts rated 10A at 35 VDC or 120 VAC
4) Switch depth behind plate: 2-1/2”
5) Switch connection via screw terminals

2.02 HARDWARE REQUIREMENTS

A. READERS – VERIFICATION DEVICES
1. All readers shall be configured with the reader electronics mounted separately on the "secure" side of the door such that only the reader head/keypad and pilot lights are mounted in the reader housing on the "entry" side of the door.

B. SMARTCARDS
1. System shall provide full compatibility with current campus contactless SmartCards read/write technology.

C. ELECTRIC LOCKSETS OR EXIT DEVICES
1. Electric lockset/panic device release provided by 080000 door hardware manufacturer. Connections by Division 28 Electronic Security Contractor which includes wiring down the door to the hardware. Interface door electrical lockset/panic device release system to local card access control panel at the local doors terminal cabinet serving that area.
2. No Maglocks shall be used

D. DOOR CONTACTS
1. Provide, where shown on drawings, UL listed magnetic flush mounted contacts and magnets. Each contact shall be provided with a matching magnet. All contacts shall be hermetically sealed for a long term 10,000,000 cycle contact. Switch contacts shall be of the reed blade type with rhodium plating eliminating cold-welding, sticking and resistance build-up. All switches shall be 100 percent factory tested prior to installation. Coordinate with door frame manufacturer and supervised.

E. OPERABLE DOOR SWITCH
1. Provide, where shown on drawings, 1-gang operable door button

2.03 SOFTWARE REQUIREMENTS

A. CCURE 9000 Software
1. Must check with Wake Tech to see what licenses may be needed to complete this work.
a. Furnish and install any needed licenses.

2.04 WIRE AND CABLE

A. Comply with requirements in Division 280513. Size conductors as indicated, but not less than recommended by the system manufacturer.

B. Furnish and install standard manufacturer's cable assemblies for components, as recommended by the system manufacturer. Include connections for electric lockset/panic device, card reader connections and all required peripheral devices.

2.05 ADA REQUIREMENTS

A. Refer to Drawings and Division 08 Openings for any systems that may require tying into.

B. Coordinate with Door Hardware Provider for installation.

PART 3 - EXECUTION

3.01 REPORTABILITY

A. Wake Tech has deployed a centrally managed Physical Access Control System for all university facilities.
   1. All doors with card readers shall be programmed with door forced and door help open alarms and report back to the CCure 9000 system.
   2. All exterior doors without card readers shall be programmed with door forced and door help open alarms and report back to the CCure 9000 system.

3.02 EXAMINATION

A. Examine conditions, with the installer present, for compliance with requirements and other factors affecting the performance of the security access system work.

B. Do not proceed until satisfactory conditions have been corrected.

3.03 INSTALLATION REQUIREMENTS

A. Installation Vendor to be Software House C-Cure 9000 certified and located within 100 miles from the job site, if possible.

B. All access control devices must be accessible.

C. Cabinets shall be mounted per provided Wake Tech details.

D. Nominal Card Reader Mounting Height: Card readers shall be mounted at the following heights:
   1. Interior: 48 inches to center above the finished floor
   2. Exterior: 48 inches to center above the finished floor
   3. Elevators: 48 inches to center above the finished floor
   4. Bollard Mount: 48 inches to center above the walkway

E. Readers to be programmed using OSDP format.

F. Each wire shall be identified at both ends with the wire designation corresponding to the wire numbers shown on the wiring diagrams.

G. All exposed wiring within the cabinets, consoles, and terminals shall be formed neatly with wires grouped in bundles using non-metallic, flame-resistant wiring cleats or wire ties.

H. All ferrous metal work shall be painted in accordance with the manufacturer’s standards.

I. Coordinate installation of door contacts with door/door hardware manufacturer. All wiring shall be concealed within doorframe and fished/routed within building walls, where not accessible with conduits.

3.04 SYSTEM WIRING

A. Provide system and device wiring as recommended by the manufacturer. All wiring shall be concealed. Route system cabling in J-hooks above ceiling or in crawlspace as required. Install in surface raceway in other areas.

B. Field wiring must be one piece from source terminal to destination terminal. Splices in field wiring will NOT be allowed.

C. All wiring splices, junctions, and taps to connect door hardware shall be in serviceable locations; without resorting to removal of door, glass, wall sections, etc.; to facilitate maintenance of the entire application.

D. Cable, wires and conductors shall be cut so that a minimum of 5 feet length is left for future service on panel and door side.

3.05 TESTING AND COMMISSIONING

A. Commissioning shall be performed by:
   1. Wake Tech approved system integrator - commissions the electronic systems
   2. Wake Tech approved hardware integrator - commissions the doors and hardware functionality

B. Wake Tech representatives shall be an integral part of the commissioning process.

C. The procedure for testing shall be followed closely in accordance with the Site Protection Pre-Functional and Functional (ATP) tests as supplied by Wake Tech. Pre-functional testing shall be performed by both the system integrator and the hardware integrator. Functional testing shall be performed by the hardware integrator.

3.06 WARRANTY

A. All equipment furnished under this contract shall be warranted for a period of twelve (12) months from the date of final Engineer/Owner acceptance of the system.

B. Respond to service requests on-site, if required.

C. Replace or repair defective components as required.

END OF SECTION

SSECTION 28 23 00 - VIDEO SURVEILLANCE SYSTEM

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Wake Technical Community College Electronic Security System Guidelines

1.02 SUMMARY

A. The Video Surveillance System shall be manufactured by Salient and compatible with the existing campus wide Video Surveillance System. It shall be connected to the existing Video Surveillance System via a network connection on the existing Wake Tech Campus infrastructure VLAN. The Video Surveillance System shall be connected to a dedicated normal emergency power circuit, and battery backup power shall be provided.

B. Provide labor, materials, coordination, and equipment necessary to complete the work of this Section, including, but not limited to, the following:
   1. Enterprise Edition CompleteView management software and associated licensing required for a fully functional solution
   2. Network video recorder servers and RAID 5 storage arrays
   3. Network video cameras
   4. Surge protection devices

C. It is the intent of these specifications to provide a complete workable integrated security system ready for the Client's use as described within the project documentation. Any items not specifically detailed in the drawings or described in the Specifications, but normally required to conform to the intent, are to be considered as part of the Contract.

D. These specifications are equipment and performance specifications. Actual installation shall be as indicated on drawings, specifications and/or contained within the manufacturers written installation instructions. Any discrepancies found between the specification, drawings and manufacturers' installation instructions shall be immediately brought to the attention of engineer/Client in writing at once. Installation and details indicated on the drawings shall govern if they differ from the specifications.

E. The contractor shall provide a spare camera of each type listed below
   1. Camera shall be setup and ready to be used in the case of a camera failure.

1.03 REFERENCES

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

B. Related Documents and Sections
   1. Division 01 – General Requirements
   2. Division 26 – Electrical
   3. Division 27 - Communications

C. The following codes, associations, acts and agencies, as required by law:
   1. American National Standards Institute/Electronic Industries Association/Telecommunication Industries Association (ANSI/EIA/TIA)
   2. Federal Communications Commission (FCC)
   3. National Fire Protection Association (NFPA)
   4. NFPA-70, 2011 (National Electric Code)
   5. National Electrical Safety Code (NESC)
   6. National Electrical Manufacturers Association (NEMA)
   7. Occupational Safety and Health Administration (OSHA)
   8. UL Standard for Safety
   9. International Building Code

10. International Fire Code
11. Any additional applicable local codes or amendments

D. When a discrepancy arises between the above-mentioned codes, standards or guidelines and the standards contained in this document, it shall be brought to the attention of the Owner immediately for resolution. The more stringent of the two guidelines shall be implemented.

1.04 SYSTEM DESCRIPTION

A. Overview
1. The video surveillance system shall have the following components and capabilities.
a. Video surveillance systems shall include digital recording, multiplexing and Internet-based server capabilities.
b. Exterior cameras shall be both environmentally protected and heated. Provisions for preventing snow and ice build-up shall be included. Daytime and nighttime cameras that are equipped with an electronic auto iris are required for all exterior applications if analog, day/night if IP.
c. Interior cameras shall be premium grade and provide high resolution color images. Applications that have variable lighting conditions shall require an auto iris lens on each interior camera.
2. Cameras will be served by Owner provided network switches located in telecommunication rooms and utilize Owner provided LAN to communicate with the network recording servers for video storage.
3. Cabling (PoE network connectivity) for the network cameras shall follow requirements as detailed within the Division 27000 specifications. Network cabling will be provided by the Telecommunications Contractor and will be terminated at the camera location utilizing an 8 position 8 contact (8P8C) modular connector. Factory manufactured and certified patch cords for use as the final camera connection will be furnished by the Telecommunication Contractor and installed by the Electronic Security Systems contractor. Additional cable requirements (power, control, etc.) shall be provided by the Electronic Security Systems contractor.
4. The Electronic Security Systems contractor shall be responsible for the coordination and providing the interface for all the systems, but also interfacing and coordinating the signals from other systems including the Access Control System, Emergency Communication System, and Other Systems in the Future

B. Scope of Work includes, but is not limited to, the following
1. Provide video management license fees to support the cameras and security devices shown on the project drawings.
2. Provide network Fixed, Fisheye, and Multi Sensor cameras as shown on project drawings including all required mounting hardware.
3. PTZ cameras shall not be used

1.05 SUBMITTALS

A. Refer to Division 1 and the General Provisions of the Contract for exact submittal procedures.

B. It will be assumed that the Contractor has examined the shop drawings and equipment brochures prior to submission and that materials and equipment depicted will readily fit into the construction. Contractor shall also review all completed work related to materials or equipment depicted to ensure that it has been properly installed.

C. Provide Storage Calculation for each camera providing images per second, frame rate, video compression used, and days of storage

PART 2 PRODUCTS

2.01 GENERAL

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are available.

B. When more than one unit of the same class of equipment or material is required, such units shall be the products of a single manufacturer and part number.

C. Unless otherwise noted, all materials and equipment shall be new, of the type, capacity, and quality specified and free from defects. Material shall bear the label of or be listed by the Underwriters' Laboratories (U.L.) unless of a type for which label or listing service is not provided.

2.02 VIDEO SURVEILLANCE SOFTWARE

A. Application: Software that provides remote video monitoring, recording, and event management functionality without being dependent on specific hardware.

B. Video Management Software:
   1. Salient CompleteView
      a. Enterprise Edition

C. Licensing
   1. Contractor shall provide all licensing as required to support the streaming and recording of all cameras furnished under this contract on to the existing Video Management platform.
      a. Salient SMAE5 - Five Year Software Maintenance Agreement for CompleteView Ent - per camera license
      b. Salient SPEI - 1 IP camera license

2.03 NETWORK VIDEO RECORDER SERVERS

A. Application: Dedicated servers for network video management and recording.

B. Digital Video Recording Servers
   1. Provided by Contractor
      a. Salient PS550T5B Intel Xeon CPU; 32GB RAM; Server 2019 Standard Emb 64 Bit; Warranty:5 year Basic: Keyboard & mouse included OS Drive RAID 1; Video Storage RAID 5; rev:005
   2. Programmed by Contractor for 30 days of storage retention at 10ips. Please add 20% buffer for future expansion.

2.04 EXTERIOR/INTERIOR DOME (TYPE A)

A. Application
   1. 4MP IR Vandal Dome

B. Acceptable Manufacturers
   1. Hanwha QNV-7082R (BOD)
   2. Product Substitution Form submitted and accepted by Engineer and Wake Tech.

C. Camera
   1. Imager
      a. Imaging Device: 1/3" CMOS
      b. Lens: 3.2~10mm(3.1x) motorized varifocal, F1.6-2.9, Horizontal field of view 98.6 - 30.8 degrees, Vertical field of view 52.3 - 17.3 degrees
      c. Illumination: Color : 0.1Lux (F1.6, 1/30sec) , B/W : 0Lux (IR LED On)
      d. Shutter Speed: Minimum/Maximum/Anti flicker (1/5~1/12,000sec)
   2. Video
      a. Video Compression: H.265/H.264 : Main/High, MJPEG
      b. Resolution: 2560x1440, 1920x1080, 1280x960, 1280x720, 800x600, 800x448, 720x576, 720x480, 640x480, 640x360, 320x240
      c. Frame Rate: H.265/H.264 : Max. 30fps at 4M all resolutions, MJPEG : Max. 15fps
      d. Streaming
         1) Unicast (6 users) / Multicast
         2) Multiple streaming (Up to 3 profiles)
   3. Network
      a. Security: HTTPS(SSL) Login Authentication, Digest Login Authentication, IP Address Filtering, User access Log, 802.1X Authentication

b. Protocols: IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP, RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, PPPoE, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, PIM-SM, UPnP, Bonjour, LLDP

4. General
   a. IP66, IK10 ratings
5. Power
   a. Input Voltage: PoE(IEEE802.3af, Class3), 12VDC
   b. Power Consumption PoE: Max 11.4W, typical 8.5W, 12VDC: Max 9.6W, typical 7.2W
   c. Operating Conditions: -40°C~+55°C (-40°F~+131°F) / Less than 95% RH
6. Provide (1) one spare camera

2.05 INTERIOR 360 FISHEYE CAMERA (TYPE B)

A. Application: 6MP Sensor Fisheye Camera for elevator use.

B. Acceptable Manufacturers
   1. Hanwha XNF-8010R (BOD)
   2. Product Substitution Form submitted and accepted by Engineer and Wake Tech.

C. Camera
   1. Imager
      a. Imaging Device: 1/1.8" 6M CMOS
      b. Lens: 1.6mm / F1.6
      c. Illumination: Color : 0.1 Lux (F1.6), B/W : 0 Lux (IR LED On)
      d. Shutter Speed: Minimum / Maximum / Anti flicker (2 - 1/12,000sec)
   2. Video
      a. Video Compression: H.265 / H.264 / MJPEG
      b. Resolution:
         1) Original view : 2048 x 2048, 1280 x 1280, 1080 x 1080, 960 x 960, 768 x 768, 720 x 720, 640 x 640, 480 x 480
         2) Single panorama : 2048 x 512, 1920 x 480, 1280 x 320, 640 x 160, 704 x 176
         3) Double panorama : 2048 x 1024, 1920 x 960, 1280 x 640, 640 x 320, 704 x 352
         4) Quad View : 2048 x 1536, 1600 x 1200, 1280 x 960, 1024 x 768, 800 x 600, 640 x 480, 704 x 576
         5) [Q1 / 2 / 3 / 4] 1024 x 768, 800 x 600, 640 x 480
      c. Frame Rate: H.265 / H.264 : 30fps@2,048 x 2,048, MJPEG : Max. 15fps
      d. Streaming: Unicast / Multicast, Multiple streaming (Up to 10 profiles)
   3. Network
      a. Security: HTTPS(SSL) Login Authentication, Digest Login Authentication, IP Address Filtering, User access Log, 802.1X Authentication
      b. Protocols: TCP/IP, UDP/IP, RTP (UDP), RTP (TCP), RTCP,RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, PPPoE, FTP, SMTP,
   4. General
      a. IP66
   5. Power
      a. Input Voltage: PoE(IEEE802.3af, Class3), 12VDC
      b. Power Consumption PoE: Max 11W, 12VDC: Max 12W
      c. Operating Conditions:-10°C - +55°C (+14°F - +131°F) / Less than 90% RH
   6. Provide (1) one spare camera

2.06 INTERIOR/EXTERIOR MULTI LENS CAMERA (TYPE C)

A. Application: 6MP x 2 Lens IR Dome for stairwells, hallways, and 180 degree interior or exterior needs.

B. Acceptable Manufacturers
   1. Hanwha PNM-12082RVD
   2. Product Substitution Form submitted and accepted by Engineer and Wake Tech.

C. Camera

1. Imager
   a. Imaging Device: 1/2.8" CMOS x 2CH
   b. Lens: 3.54~6.69mm(1.9x) motorized varifocal, F1.67-2.64, Horizontal field of view 96 - 47 degrees, Vertical field of view 51 - 26 degrees
   c. Illumination: Color: 0.16lux(F1.67, 1/30sec, 30IRE) , BW: 0.016lux(F1.67, 1/30sec, 30IRE), 0lux(IR LED on)
   d. Shutter Speed: Minimum / Maximum / Anti flicker (2 ~1/12,000sec)
2. Video
   a. Video Compression: H.265/H.264: Main/Baseline/High, MJPEG
   b. Resolution: 3328x1872, 3072x1728, 2592x1944, 2688x1520, 1920x1080, 1600x1200, 1280x1024, 1280x960, 1280x720, 1024x768, 800x600, 800x448, 720x576, 720x480, 640x480, 640x360, 320x240
   c. Frame Rate: H.265/H.264: 6MP Max.15fps , MJPEG : Max. 15fps
   d. Streaming: Unicast(20 users) / Multicast, Multiple streaming (Up to 10 profiles)
3. Network
   a. Security: TPM 2.0 (FIPS 140-2 level 2), HTTPS(SSL) Login Authentication, Digest Login Authentication, IP Address Filtering, User access log, 802.1X Authentication(EAP-TLS, EAP-LEAP, EAP-PEAP MSCHAPv2), Device Certificate(Hanwha Techwin Root CA, pre-installed), Secure by default certificate, Secure OS/Boot/Storage, Verify firmware forgery
   b. Protocols: IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP,RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, UPnP, Bonjour, LLDP, SRTP (TCP, UDP Unicast)
4. General
   a. IP66/IP67, NEMA4X, IK10
5. Power
   a. Input Voltage: PoE+(IEEE802.3at, Class4)
   b. Power Consumption PoE+: Max 18.3W, typical 13.5W
   c. Operating Conditions: -40°C~+55°C(-40°F ~ +131°F) / Less than 95% RH(Non-condensing.
6. Provide (1) one spare camera

2.07 EXTERIOR/INTERIOR MULTI-SENSOR CAMERA (TYPE D)

A. Application: 20MP (5MP x 4) Multi-Sensor, Multi-Directional PTRZ Camera to view 4 independent views or a 360 view.

B. Acceptable Manufacturers
   1. Hanwha PNM-9085RQZ1
   2. Product Substitution Form submitted and accepted by Engineer and Wake Tech.

C. Camera
   1. Imager
      a. 1/1.8" 5MP CMOS x 4CH
      b. Lens: 4.13~9.4mm (2.3x) motorized varifocal, F1.92 - F2.67, Horizontal field of view 87.58 - 37.34 degrees, Vertical field of view 64.58 - 28.04 degrees
      c. Illumination: Color: 0.11lux(F1.92, 30 IRE) BW: 0Lux(IR LED on)
      d. Shutter Speed: Minimum / Maximum / Anti flicker (2 ~1/12,000sec)
   2. Video
      a. Video Compression: H.265/H.264: Main/Baseline/High, MJPEG
      b. Resolution: 2560x1920, 2560x1440, 1920x1080, 1600x1200, 1280x1024, 1280x960, 1280x720, 1024x768, 800x600, 800x448, 720x576, 720x480, 640x480, 640x360, 320x240
      c. Frame Rate: 30fps/25fps (60Hz/50Hz) at all resolutions Max. 30fps/25fps (60Hz/50Hz)
      d. Streaming: Unicast(20 users) / Multicast Multiple streaming(Up to 10 profiles)

3. Network
    a. Security: HTTPS(SSL) Login Authentication Digest Login Authentication IP Address Filtering User access log 802.1X Authentication(EAP-TLS, EAP-LEAP) Device Certificate(Hanwha Techwin Root CA)
    b. Protocols: IPv4, IPv6, TCP/IP, UDP/IP, RTP(UDP), RTP(TCP), RTCP,RTSP, NTP, HTTP, HTTPS, SSL/TLS, DHCP, FTP, SMTP, ICMP, IGMP, SNMPv1/v2c/v3(MIB-2), ARP, DNS, DDNS, QoS, PIM-SM, UPnP, Bonjour, LLDP
4. General
    a. IP66, NEMA4X, IK10
5. Power
    a. Input Voltage: HPoE(IEEE802.3bt, Class6, Type3, Injector included), 12VDC
    b. Power Consumption PoE: Max. 45 W, Typical 33.7 W 12VDC: Max. 42 W, Typical 32 W
    c. Operating Conditions: -40°C~+55°C(-40°F ~ +131°F) / Less than 90% RH(Non-condensing)
6. Provide (1) one spare camera

2.08 CAMERA SURGE PROTECTION DEVICES

A. Application: Protects circuits and devices that use PoE connections.

B. Provide surge protection devices for all exterior cameras.

C. Surge Protection Devices
    1. Features
        a. Protects power, video, and data on network-based security cameras.
        b. Supports GbE without signal degradation.
        c. Compliant with IEEE 802.3af and 802.3at for PoE and High PoE
    2. General
        a. Connectors: RJ45 connection with external grounding screw
        b. Data rate: Gigabit Ethernet
        c. Max Continuous Current: 1.5 Amps
        d. Dissipation: 3,000W
        e. Protection Mode: Line-Ground

D. Manufactures
    1. Ditek
        a. #DTK-MRJPOE, single channel surge protection device
        b. #DTK-RM12NETS, 12-channel surge protection device
    2. Product Substitution Form submitted and accepted by Engineer and Wake Tech.

PART 3 EXECUTION

3.01 GENERAL

A. Contractor shall coordinate with all other trades prior to installation. Meeting with the Electrical Communications, and General Contractors to identify pathways and infrastructure space requirements.

B. Install all system components including Owner furnished equipment, and appurtenances in accordance with the manufacturer's instructions, and as shown, and shall furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

C. Visit the site and verify that site conditions are in agreement with the design package. Report all changes to the site or conditions that will affect performance of the system to the Owner in a report. The Contractor shall not take any corrective action without written permission from the Owner and Owner.

D. The Contractor shall perform a field survey and furnish a report to the Owner as part of the site survey report. The Contractor shall be held responsible for repair costs due to Contractor negligence or abuse of Owner equipment.

E. Verify that all surfaces and areas are ready to receive work.

F. Verify field measurements as shown on drawings and as instructed by manufacturer.

G. Verify that required utilities are available, in proper location, and ready for use.

3.02 DIMENSIONS AND DEFINITE LOCATIONS

A. The Project Drawings depicting work show approximate locations. The exact location of equipment and devices shall be established in the field in accordance with instructions from the owner. Consideration shall be given to construction features, landscaping, equipment of other trades, and requirements of the equipment proper

B. The Contractor shall refer to shop drawings and submittal drawings for equipment requiring electrical connections to verify rough-in and connection locations.

C. Unless specifically stated to the contrary, no drawings by scale shall be used as a dimension to work by. Dimensions noted on the drawings are subject, in each case, to measurements of adjacent or previously completed work and all such measurements necessary shall be taken before undertaking any work dependent upon them.

3.03 INSTALLATION

A. General
   1. Installation vendor to be Salient CompleteView Enterprise Edition certified and located within 100 miles of the job site, if possible.
   2. Install the video surveillance system related equipment as specified by the manufacturer and as shown, provide mounting hardware sized appropriately to secure each device for conditions encountered at the site; connect signal lines and AC power to equipment.
   3. Ensure that:
      a. All applicable statutes, ordinances, regulations, license requirements and codes are fully complied with.
      b. All required permits are obtained.
      c. All required inspections are conducted.
      d. All necessary certificates are issues, obtained, and delivered to the Owner.
      e. All equipment installations and mounting are in strict accordance with requirements for applicable seismic classification.

B. Video Management Software
   1. Coordinate with Owner’s IT and Security representatives to set the following criteria:
      a. Administrator and operator passwords
      b. Camera and video device nomenclature
      c. Maximum bitrate and bandwidth throttle, if any
         1) Bit rate assumptions
            (a) 2MP Camera 2-4Mbps per lens
            (b) 5MP Camera 5-8Mbps per lens
            (c) 6MP Camera 6-9Mbps per lens
            (d) 8 or 12MP Camera 8-14Mbps per lens
      d. Camera groups, salvos, and operator views
      e. Mapping features and criteria for a fully interactive graphical display of each floor plan
      f. Alarm events and integration into the access control system and other subsystems

C. Network Video Recorders
   1. Rack mount servers and storage arrays in Building MDF . Coordinate with Owner’s IT and Security representatives for exact location.

D. Network Cameras

1. Provide flush ceiling mount kit for fixed network cameras within interior accessible ceiling space. Install camera body above ceiling line so only lower polycarbonate dome and trim ring is exposed.
2. Provide outdoor rated housings and mounts for exterior cameras with built in heaters.
3. Prior to installation, coordinate with electrical contractor to confirm exact placement of cameras for conduit and rough-in requirements.
4. Field determine exact placement of cameras installed in interior accessible ceiling to ensure complete coverage of targeted area.
5. Adjust the wide dynamic range, gain control, and noise reduction settings on each camera as required to provide clear and crisp video images.

3.04 PROGRESSIVE AND FINAL CLEANING OF PROJECT SITE

A. During construction, and prior to the Owners acceptance of the building, remove from the premises and dispose of packing material and debris cause by communications work.

B. Remove dust and debris from interior and exterior of telecommunications equipment. Clean accessible current carrying equipment prior to being energized.

C. Contractor shall clean work areas each day and remove debris properly and legally from the Owner's property. Where communications equipment and related materials are installed or stored for use in the project shall be neatly stacked and remain free of debris, cable scraps and accumulated dust from the floor and surfaces of installed communication equipment, and materials. All exits and paths shall be cleaned to prevent dirt from being tracked throughout the facility.

D. Upon completion of the work, remove excess debris, materials, equipment, tools, and similar items. Leave the premises clean, neat, and orderly.

3.05 CAMERA SURGE PROTECTION

A. Connect incoming horizontal UTP cabling in the IN connector. Connect the camera's UTP patch cable to the OUT connector to be protected.

B. Use common ground per device to eliminate the possibility of a differential in ground potentials.

3.06 TESTING

A. General
1. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all site testing. The Owner will witness all performance verification. Written permission shall be obtained from the Owner before proceeding with the next phase of testing. Original copies of all data produced during performance verification shall be turned over to the Owner at the conclusion of each phase of testing prior to Owner approval of the test.
2. Coordinate testing requirements with the General Contractor and provide specific information on pre-acceptance and final acceptance testing activities so that they can be entered into the overall construction schedule.

B. Cable Testing
1. All cables and termination hardware shall be 100% tested for defects in the installation and the materials used to verify performance under installed conditions. All conductors of each installed cable and system component shall be verified usable by the contractor.
2. Testing for the horizontal structured cabling serving the video surveillance system provided by under Section 271513 - Communications Horizontal Copper Cabling.

C. Pre-Acceptance Testing
1. The Contractor shall perform a 100% pre-acceptance test to verify operation of the video surveillance system prior to the final acceptance test with the Owner.
2. Pre-Acceptance Testing activities shall not occur until Contractor has ensured that all punch list items have been remedied. If conditions exist that may cause degradation or interference with any security device, the Contractor shall inform the Owner.
3. The pre-acceptance testing shall, as a minimum, include:

a. Verification that all signal or control cabling under this contract has been installed, tested, and approved as specified.
b. Verification that cameras are properly installed and provide clear, crisp images in the specified format and resolution.
c. Verification that current recording configuration provides the minimum required storage (i.e., 30 days, etc.) as noted in this section.
d. Verification that client software is able to view live video and recorded video. Verify graphical mapping and alarm management screens.
e. Verify integration with specified access control system for automatic camera call-up on alarm with proper alarm/event recording parameters.

4. Document the results of the pre-acceptance testing using approved test forms. Report shall indicate the system has been properly calibrated, tested, and is ready to begin final acceptance testing with the Owner.

D. Acceptance Testing
1. Upon successful completion of Pre-Acceptance Testing, the Contractor shall demonstrate to the Owner that the completed video surveillance system complies with the contractor requirements. Acceptance Testing shall not commence until receipt of approved Pre-Acceptance Testing activities based on the Contractor's written report.
2. Using approved test procedures, all physical and functional requirements of the project shall be demonstrated and shown.
3. The Owner may terminate Acceptance Testing at any time when the system fails to perform as specified. Upon termination of testing by the Owner or by the Contractor, the Contractor shall submit a report outlining the required repairs to the Owner then commence system repairs upon direction by the Owner. Upon successful completion of the Acceptance Testing, the Contractor shall deliver test reports and other documentation as specified to the Owner.

3.07 WARRANTY

A. All equipment furnished under this contract shall be warranted for a period of twelve (12) months from the date of final Engineer/Owner acceptance of the system.

B. Respond to service requests on-site, if required.

C. Replace or Repair defective components as required.

END OF SECTION

SECTION 28 31 11 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Projected Beam Type detectors.
5. Heat detectors.
6. Firefighters' two-way telephone communication service.
7. Notification appliances.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.
11. System printer.
12. Bi-Directional Antenna System (BDA)

1.02 CODES AND STANDARDS:

A. ANSI/ASME AII Safety Code for elevators and escalators.

B. Factory Mutual (FM), FM AG Approval Guide

C. NFPA Standards 101, 72, 1221 and 90A, latest edition.

D. National Electrical Code, latest edition.

E. Local Building Code.

F. Requirements of local Fire Departments.

G. UL Publication.

1.03 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

C. FACP: Fire alarm control panel.

1.04 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice/strobe evacuation.

1.05 SUBMITTALS

A. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Engineer.
2. Shop Drawings shall be prepared by persons with the following qualifications:
a. Trained and certified by manufacturer in fire-alarm system design on the specific fire alarm system being installed on this project.
1) The factory training and certification must have occurred within the most recent 24 months.
2) Copies of the certification must be part of the Contractor’s submittal to the Engineer prior to installation.
3) The submittal will not be approved without this certification.
b. In addition to the requirement for factory certification the person preparing the shop drawings shall be a NICET-certified fire-alarm technician, Level III minimum.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For fire-alarm system. The submittal shall include all required items as indicated below. Partial submittals are not acceptable and will be rejected.
   1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
   2. Include voltage drop calculations for notification appliance circuits.
      a. End Of Line (EOL) voltage drop must not exceed 14% of the expected battery voltage.
      b. Submit calculations indicating compliance with this criteria.
   3. Include battery-size calculations.
      a. Battery:
         1) Sizing calculations showing compliance for:
            a) Provide 24-hours battery capacity while in the alarm mode for 5-minutes.
         2) Submit battery information indicating the rating of each battery that will be used on this project.
   4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
   5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
   6. Include Floor Plans:
      a. Indicate final outlet locations and routing of cable and conduits.
      b. Show locations for isolation modules, terminal cabinet boxes, FACP, RAAP, NAP power supplies, and main FACP battery cabinet. Isolation modules shall not be located in the FACP.
      c. Show address of each addressable device.
   7. Include Reflected Ceiling Plans:
      a. Show locations for all ceiling mounted devices, fully coordinated with all other trades including, but not limited to Lighting, HVAC, Plumbing, Fire Protection, Telecom, Security, and A/V.
   8. Include riser diagram:
      a. Indicate fire alarm system per the planned installation.
      b. Indicate wiring circuits, and wire sizes.
      c. Indicate Terminal cabinet locations.
   9. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
   10. Device Address List:
      a. Coordinate with final system programming.
      b. Coordinate with Owner for final naming convention and room names to identify location of devices.
   11. System Operation Description:
      a. Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs.
      b. Manufacturer’s standard descriptions for generic systems are not acceptable.

D. Operating Instructions: For mounting at the FACP.

E. Product Certificates: Signed by manufacturers of system components certifying that products furnished comply with requirements.

F. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with NFPA 72.

G. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 1. Comply with NFPA 72.

H. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 01 Section “Submittal Procedures,” make an identical submission to authorities having jurisdiction. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Engineer for review.

I. Certificate of Completion: Comply with NFPA 72.

J. Field quality-control reports.

K. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   3. Record copy of site-specific software.
   4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
      a. Frequency of testing of installed components.
      b. Frequency of inspection of installed components.
      c. Requirements and recommendations related to results of maintenance.
      d. Manufacturer's user training manuals.
   5. Manufacturer's required maintenance related to system warranty requirements.
   6. Abbreviated operating instructions for mounting at fire-alarm control unit.

L. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: All persons terminating wiring, installing fire alarm system devices and /or programming the fire alarm systems shall meet the following minimum requirements:
   1. Trained and certified by manufacturer in fire-alarm system design on the specific fire alarm system being installed on this project.
      a. The factory training and certification must have occurred within the most recent 24 months. The manufacturer must sign the certification certifying the installer’s compliance with their requirements.
      b. Copies of the certification must be part of the Contractor’s submittal to the Engineer prior to installation.

B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Certification: Obtain certification according to NFPA 72 by compliance with the Engineer’s witness test. Refer to Part 3 – Execution.

1.07 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Final Acceptance, provide software support for one year.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within one year from date of Final Acceptance. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.08 MAINTENANCE MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps for Remote Indicating Lamp Units: Quantity equal to 5 percent of amount installed, but no fewer than 2 units.
   2. Lamps for Strobe Units: Quantity equal to 5 percent of amount installed, but no fewer than 2 units.
   3. Smoke Detectors and Fire Detectors: Quantity equal to 6 percent of amount of each type installed, but no fewer than 1 unit of each type.
   4. Detector Bases: Quantity equal to 6 percent of amount of each type installed, but no fewer than 1 unit of each type.
   5. Keys and Tools: One extra set for access to locked and tamper proofed components.
   6. Fuses: Two of each type installed in the system.
   7. Manual Stations: Quantity equal to 2 percent of amount installed, but no fewer than 1 unit.
   8. Indoor Notification Appliance: Quantity equal to 4 percent of each type installed, but no fewer than 1 unit of each type.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Gamewell/FCI.1
   2. Edwards; by United Technologies Corporation.
   3. NOTIFIER; by Honeywell.

2.02 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and/or systems:
   1. Manual stations.
   2. Heat detectors.
   3. Smoke detectors.
   4. Duct smoke detectors.
   5. Fire-extinguishing system operation.

B. Fire-alarm signal shall initiate the following actions:
   1. Continuously operate alarm notification appliances.
   2. Identify alarm at fire-alarm control unit and remote annunciators.
   3. Transmit an alarm signal to the remote alarm receiving station.
   4. Unlock electric door locks in designated egress paths. Refer to plans for egress paths.
   5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
      a. Unless otherwise noted on the fire alarm matrix on the drawings the default condition shall be ‘OFF’ during a general fire alarm condition with a manual override switch/control for activation by the fire department.
   6. Activate emergency lighting control.
   7. Activate emergency shutoffs for gas and fuel supplies.
   8. Recall elevators to primary or alternate recall floors.
   9. Record events in the system memory.
   10. Record events by the system printer.
   11. Activate voice/alarm communication system.

12. Shunt trip elevator power where sprinkler heads are installed in elevator shafts, machine rooms or pits.

C. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
   a. When 8-hours have elapsed after the power outage.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
10. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

D. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
   a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
   b. Programmable tone and message sequence selection.
   c. Standard digitally recorded messages for "Evacuation" and "All Clear." All messages to be verified with owner and set prior to acceptance testing.
   d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
4. The emergency voice/alarm communication system shall have the capability to broadcast live voice messages by paging zones on selective and all-call basis.
5. A manual override for emergency voice communication shall be provided on a selective and all-call basis for all paging zones.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.03 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.
2. Addressable initiation devices that communicate device identity and status.
   a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.

b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 3 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. Addressable Systems: Notification Appliance, and Signaling Line Circuits:
   a. Notification Appliance Circuits (NAC): Class A.
   b. Initiating Device Circuits: Class A, T-Taps not permitted.
   c. Signaling Line Circuits (SLC): Class A, T-Taps not permitted.
2. Serial Interfaces: Two RS-232 ports for printers.

D. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

E. Notification Appliance Circuit: Operation shall sound in the ANSI 53.41 three-pulse temporal pattern described in NFPA 72.

F. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

G. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

H. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

I. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals and supervisory signals shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium or Sealed, valve-regulated, recombinant lead acid
2. Battery Nominal Life Expectancy: 20 years, minimum.
3. Facilities without generator power to the Fire Alarm Control Panel must have 60-hours battery capacity while in the alarm mode for 5-minutes.

4. End Of Line (EOL) voltage drop must not exceed 14% of the expected battery voltage.
5. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails unless restored within 60 seconds.

K. Battery Charger:
1. Solid-state, fully automatic, variable-charging-rate type.
2. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge.
3. Whenever batteries are fully discharged, the charger shall recharge them completely within four hours.
4. Charger output is supervised as part of system power supply supervision.

L. Integral Automatic Transfer Switch:
1. Transfers the load to the battery without loss of signals or status indications when normal power fails.

M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

N. Air Handling Unit Shutdown Defeat:
1. A supervised “AHU Shutdown Defeat” switch must be provided in or adjacent to the FACP and as a key-operated function in the Remote Annunciator (where provided).
a. All smoke dampers associated with the AHU(s) shall remain in the open position while the AHU Shutdown Defeat switch has been placed in the off-normal position.
2. Whenever the Remote Annunciator option is utilized, provide an informative engraved label at the FACP about this function.
3. The switch must cause a system “trouble” indication when it’s placed in the off-normal (“AHU Shutdown Defeated”) position.

2.04 PREACTION SYSTEM

A. Initiate Presignal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a preaction system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

2.05 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Weatherproof Protective Shield (as shown on floor plans): Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.06 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
    a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
    c. Provide multiple levels of detection sensitivity for each sensor.
8. Spacing: Drawings reflect spacing based on a prescriptive design of 30 ft per NFPA 72. If smoke detector supplied cannot meet this spacing requirement, contractor is responsible for providing additional smoke detectors to cover area as indicated on the drawings.

B. Photoelectric Smoke Detectors:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

E. Remote Test Switch and Indicating Lights: All duct detectors shall have a remote test switch and indicating light installed in the nearest corridor or public area and identified by an engraved label affixed to the wall or ceiling.

2.07 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135°F or a rate of rise that exceeds 15°F per minute unless otherwise indicated.
   1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Spacing: Drawings reflect spacing based on a prescriptive design of 30 ft per NFPA 72. If heat detector supplied cannot meet this spacing requirement, contractor is responsible for providing additional heat detectors to cover area as indicated on the drawings.

2.08 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Voice/Tone Notification Appliances:
   1. Comply with UL 1480.
   2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
   3. High-Range Units: Rated 2 to 15 W.
   4. Low-Range Units: Rated 1 to 2 W.
   5. Mounting: surface mounted and bidirectional.
   6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.
   1. Rated Light Output:
      a. 15/30/75/110 cd, selectable in the field.
   2. Mounting: Wall or ceiling mounted as indicated on plans.
   3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   4. Flashing shall be in a temporal pattern, synchronized with other units.
   5. Strobe Leads: Factory connected to screw terminals.
   6. Mounting Faceplate: Factory finished.
   7. Finish Color: white.

2.09 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:
   1. Common-talk type for firefighter use only.
   2. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.
   3. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.

a. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
b. Display: Liquid-crystal digital to indicate location of caller.
c. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
   1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."
   2) With "break-glass" type door access lock.
d. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Emergency Phone."
e. Handsets: Provide push-to-talk-type sets with noise-canceling microphone stored in a cabinet. Locations as shown on the drawings.

2.10 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
   1. Mounting: Flush cabinet, NEMA 250, Type 1.
   2. Finish: White.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

C. Wall-mounted Device Location Maps indicating the building floor plan with a “You Are Here” designation.
   1. Mounting: Adjacent to remote annunciator and the FACP.

2.11 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Multi-gang Indicating Addressable devices are not permitted. All devices shall be installed in individual boxes

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: System shall be equipped with a 4-channel (minimum) DACT and also an LTE/IP Fire Alarm Communicator (Notifier HWF2 (A or V)-Com; Telguard TG-7FS; or Honeywell HW-AV-LTE-M) for transmission of fire alarm, supervisory, and trouble signals to a remote off-campus monitoring company BFPE International. DACT and Communicator shall be compatible with Owner’s fire alarm receiving equipment. Contractor shall confirm compatibility prior to installation. The fire alarm contractor shall program the PROM(s), connect DACT to wireless communicator, and verify proper signal receipt by supervising station from both the DACT and Wireless Communicator. System shall have one (1) LTE cellular and (1) IP path backup for redundant dial out capability. The transmission means shall comply with NFPA 72. Final testing and acceptance of the fire alarm system depends on proper functioning of the interconnection of the fire alarm control panel and the Owner’s supervision station.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:
   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.
   4. Manual test report function and manual transmission clear indication.

5. Communications failure with the central station or fire-alarm control unit.

D. The following signals shall be reported as applicable:
6. Address of alarm-initiating device.
7. Address of supervisory signal.
8. Address of trouble-initiating device.
9. Loss of ac supply.
10. Loss of power.
11. Low battery.
12. Abnormal test signal.
13. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

G. The installation of this device shall include the required telecommunications cabling as specified for data outlets in these specifications.

2.13 SYSTEM PRINTER

A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system. Printer shall be 120-volt ac and use ordinary (non-thermal) paper. Install as shown on drawings or as selected by Owner. For high rise buildings, the printer must be monitored by the Central FACP and be powered from an emergency circuit.
1. Provide wall shelf for mounting.
2. Provide dedicated 120-volt receptacle from same power source as the FACP.

2.14 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

2.15 WIRING

A. Non-Power-Limited Circuits: Copper conductors with 600-V rated, 75 deg C, color-coded THHN/THWN insulation.
1. Low-Voltage Circuits: Stranded No. 14 AWG, minimum.
2. Line-Voltage Circuits: Solid No. 14 AWG, minimum.

B. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.

C. Wiring shall be color coded as follows:
1. Addressable loop (signaling line) circuits shall be wired with type FPL/FPLR/FPLP fire alarm cable, low capacitance (30-pF Max.), 16 AWG minimum, twisted shielded copper pair. Cable shield drain wires are to be connected at each device on the loop to maintain continuity, taped to insulate from ground, and terminated at the FACP. Acceptable manufacturers include Atlas, Belden, West Penn or equal wire having capacitance of 30 pf/ft. maximum between conductors. The cable jacket color shall be red, with Red (+) and Black (-) conductor insulation.
2. Unshielded Cable, otherwise equal to the above, is permitted where the manufacturer’s installation instructions unequivocally require, or state a preference for, the use of unshielded cable for all systems.
3. Alarm notification appliance circuits (horns and strobes) shall be wired with type THHN/THWN, stranded copper, AWG 16 minimum, color coded Blue (+), Black (-) conductor insulation.
4. One way voice/Alarm and Two-way (Fireman’s Telephone) digital audio circuits shall be wired with low capacitance (30-pF Max.), AWG 18 minimum, twisted shielded copper pair. Cable shield drain wires are to be connected continuous from the amplifier to the end of the line. Acceptable manufacturers include Atlas, Belden, West Penn or equal wire having

capacitance of 30 pf/ft. maximum between conductors. The cable jacket shall be Gray outer jacket, Red (+), Black (-) conductor insulation.
   a. Note: Where required to meet NFPA fire rating requirements MI cable shall be utilized.
5. System equipment with 24VDC operating power shall be wired with type THHN/THWN, stranded copper, AWG 14 minimum, color coded Yellow (+), Brown (-) conductor insulation.
6. Door control circuits for maglocks if supplied from fire alarm system shall be wired with type THHN/THWN, stranded copper, AWG 14 minimum, color coded Orange conductor insulation.
7. Circuits from Zone Addressable Monitored Devices shall be wired with type THHN/THWN, stranded copper, AWG 14 minimum, color coded Violet (+), Gray (-) conductor insulation.
8. For underground circuits installed in conduit, use Type TC or PLTC cable (PE insulated) to avoid problems for moisture. Color coding for specific application, as described herein, shall be followed.

2.16 POWER SUPPLIES

A. Notification Appliance circuit booster (“ADA”) power supplies and Voice Messaging power supplies must be individually monitored for integrity and are not permitted to be located above a ceiling, or in non-conditioned space. Any 24vdc power circuits serving addressable control relays must also be monitored for integrity. Provide a smoke detector within 15 feet of the power supply.
   1. Each Power Booster shall be addressable to and supervised, per NFPA requirements, by the FACP.
   2. The FACP shall be able to distinguish each individual Power Booster and issue a digital readout for each individual Power Booster that reports a trouble signal.
   3. Provide dedicated 120-volt receptacle from the same source as the FACP.
   4. Notification Appliance circuit booster total capacity shall not be less that the total load connected to the circuit booster, as calculated from the devices Cd as shown on the drawings, plus 30% spare capacity for additional devices or a change to Cd settings.

2.17 ISOLATION MODULES

A. To minimize the impact of a wiring fault (short), isolation modules or (if the ceiling height is <10 feet) isolator base type initiating devices shall be provided as follows:
   1. After each 20 devices and control points on any addressable circuit.
   2. For each addressable circuit that extends outside the building walls.
   3. Immediately adjacent to the FACP, at each end of the addressable loop. These two isolators must be in the same room as the FACP and within 15 feet. Isolation modules shall not be located in the FACP.
   4. For loops covering more than one floor, install isolator at terminal cabinet on each floor (with additional isolator(s) on any floor with over 20 addresses).
   5. Coordinate with the Owner and the Engineer for the approved method of installation for accessibility and maintenance.

2.18 SURGE PROTECTION DEVICE

A. The following protection against voltage transients and surges must be provided by the fire alarm equipment supplier, and installed by the electrical contractor for all fire alarm system panels:
   1. On AC Input:
      a. A feed through (not a shunt-type) branch circuit transient arrestor such as the Ditek DTK, EFI HWM-120, Leviton OEM-120EFI, Northern Technologies TCS-HW, Transtector ACP100BWN3, or any equivalent UL Listed device submitted to and approved by the Engineer.
      b. Install suppressor on the outside of the electrical panelboard, and trim excess lead lengths.

c. Wind small coil in the branch circuit conductor just downstream of the suppressor connection. Coil to be wound using 5 to 10 turns, ¾”-1” diameter. The coil shall be securely tie-wrapped at two points to maintain the coil diameter and winding integrity.
   1) This series impedance will improve the effectiveness of the arrestor in suppressing voltage transients.

2. On DC Circuits Extending Outside Building:
   a. Acceptable models: Simples 2081-9027 and 2081-9028, Transtector TSP8601, the Ditek DTKxLVL series, Citel American BF280-24V, Northern Technologies DLP-42. Equal products may be submitted to the Engineer for approval.
   b. Adjacent to the FACP, and also near point of entry to outlying building, provide “pi” type filter on each leg, consisting of a primary arrestor, a series impedance, and a fast acting secondary arrestor which clamps at 30v to 40v.

2.19 BI-DIRECTIONAL ANTENNA (BDA) SYSTEMS

A. Building Radio Coverage. Except as otherwise provided no personal shall maintain, own, erect, or construct, any building or structure or any part thereof, or cause the same to be done which fails to support adequate radio coverage for public safety entities, including, but not limited to, firefighters, emergency medical services and police officers. "Agency" as used in this code means the local governmental authority enacting this code.

B. Minimum Radio Coverage into building. A minimum voice quality of DAQ 3.4 (see TSB-88-B) (for Digital radio systems) and Circuit Merit 3 (for Analog systems) be present in all areas of the building when transmitted from the agency's radio system. A minimum average in-building field strength of 3.9uV (-95bDm) throughout 95% off the building. For purposes of this section, 95% building coverage is considered to all areas of the building.

C. Minimum Signal Strength out of building. A minimum signal strength of 15 db above the noise floor shall be provided to and from the agency's radio system when transmitted or received from all areas of the building. For purposes of this section, 95% building coverage is considered to be all areas of the building.

D. Technical criteria maintained by the Agency. The agency shall maintain a document of technical information specific to their requirements. This document shall contain as a minimum; the frequencies required the location and effective radiated power (ERP) of radio sites used by the in-building system, the maximum propagation delay (in microseconds) and other supporting technical information.

E. Amplification Systems Allowed. Buildings and structures which cannot support the required level of radio coverage shall be equipped with a distributed antenna system (DAS) with FCC certified Bi-Directional Amplifier (BDA)s (AKA: bi-directional amplifiers), or systems otherwise approved by the agency in order to achieve the required adequate radio coverage

F. Battery Systems. The active components of the installed system or systems shall be capable of operating on an independent battery system for a period of at least twenty-four (24) hours without external power input. The battery system shall automatically charge in the presence of external power input.

G. Bi-Directional Amplifier (BDA) requirements. Bi-Directional Amplifier (BDA) shall meet the following requirements as well as any other requirements determined by the agency.
   1. All Bi-Directional Amplifier (BDA) components shall be contained in one NEMA4 type waterproof cabinet. Permanent external filters and attachments are not permitted.
   2. The battery system shall be contained in one NEMA4 type water proof cabinet.
   3. The system shall be capable of providing automatic alarming of malfunctions of the Bi-Directional Amplifier (BDA) and battery system. Any resulting alarm shall be transmitted to the agency's designated recipient by means specified by the agency, including, but not limited to, automatic standard telephone dial-up circuit, TCPAP network circuit, RS232 interface, etc.
   4. Products used in such systems must have FCC Certification prior to installation. Pending FCC certification is not acceptable.

5. All Bi-Directional Amplifier (BDA)s must be compatible with both analog and digital communications simultaneously at the time of installation.
6. The frequencies used shall be those that are currently in use by the Wendell Fire/Rescue Department (700/800 MHz). This BDA system shall also accommodate the 24 MHz of public safety spectrum, being redesigned for broadband use to allow for nationwide interoperable broadband communications by public safety users.
7. All BDA equipment, cable and antenna systems shall be grounded with a single point ground system of five (5) ohms or less. Ground system shall include an internal tie point within three (3) feet of the amplification equipment.

H. Additional frequencies and change of frequencies. The building owner will be required to modify or expand the public safety in-building system in the event frequency changes are required by the FCC or additional frequencies are made available by the FCC. This is an advisory statement that the building owner may select equipment and distribution components that are capable of such changes. Prior approval of an in-building system on previous frequencies does not exempt this section.

I. Approval for Prior to Installation. No amplification system capable of operating on frequencies licensed to the agency by the FCC shall be installed without prior coordination and approval of the agency. This is a FCC requirement.

J. Implementation. The Bi-Directional Amplifier (BDA) system(s) shall only be implemented by professional system integrator certified and trained by the manufacturer of the Bi-Directional Amplifier (BDA).

K. Documentation. As-built drawings consisting of a system block diagram, layout drawings and data settings, shall be provided electronically in AutoCAD format on CD and in paper copies (2) to the agency.

L. Testing and Proof of Compliance. Each owner shall submit at least one in-building coverage test:
1. Acceptance testing prior to occupancy of any newly constructed building.
2. Whenever structural changes occur including additions to buildings that would materially change the original field performance test.
3. Annually.
4. When repairs or alterations are made to amplification systems, the performance test shall demonstrate that adequate radio coverage is available in all required areas of the building. At the conclusion of the testing a report shall be submitted to the agency which shall verify compliance with Section 1.2.

M. Acceptance Test Procedure. When an in building radio system is required, and upon completion of installation, it will be the building owner's responsibility to have the radio system tested to ensure that two-way coverage on each floor of the building is a minimum of 95 percent.
1. Each floor of the building shall be divided into a grid of approximately 40 equal areas. A maximum of two nonadjacent areas will be allowed to fail the test.
2. In the event that three of the areas fail the test, in order to be more statistically accurate, the floor may be divided into 40 equal areas. A maximum of four nonadjacent areas will be allowed to fail the test. After the 40-area test, if the system continues to fail, it will be the building owner's responsibility to have the system altered to meet the 95 percent coverage requirement.
3. The test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications system.
4. A test location approximately in the center of each grid area will be selected for the test, then the radio will be enabled to verify two-way communications to and from the outside of the building through the agency's radio communications system. Once the test location has been selected, prospecting for a better spot within the grid area will be permitted within 3' in any direction of the original selected test location.
5. Isolation Testing. As part of the installation a spectrum analyzer or other suitable test equipment shall be utilized to insure spurious oscillations are not being generated by the

subject Bi-Directional Amplifier (BDA) due to coupling (lack of sufficient isolation) between the input and output antenna systems. The test will be conducted at time of installation and subsequent annual inspections.

N. System Settings. The gain and power values of all Bi-Directional Amplifier (BDA)s shall be measured. The test measurement results shall be recorded on as-built drawings and kept on file with the building owner so that the measurements can be verified each year during the annual tests. In the event that the measurement results become lost, the building owner will be required to rerun the acceptance test to reestablish the gain values.

O. Annual Tests. When an in-building radio system is required, it shall be the building owner's responsibility to have all active components of the system, such as Bi-Directional Amplifier (BDA)s, power supplies and backup batteries test to a minimum of once every twelve (12) months. Bi-Directional Amplifier (BDA)s shall be tested to ensure that the gain and power are the same as it was upon initial installation and acceptance. Backup batteries and power supplies shall be tested under load of a period of one hour to verify that they will properly operated during an actual power outage. If within the one-hour test period, and in the opinion of the agency's representative, the battery exhibits symptoms of failure, the test shall be extended for additional one-hour periods until the integrity of the battery can be determined. All other active components shall be checked to determine that they are operating within the manufacturers specifications for the intended purpose.

P. Field Testing. Police and Fire Personnel shall at any time have the right to enter onto the property to conduct its own field-testing to be certain that the required level of radio coverage is present.

Q. Minimum qualifications of personnel. The minimum qualifications of the system engineer and integration organization shall include:
1. A Valid Professional Engineering Certification
2. Certification of in-building system training issued by the manufacturer of the equipment being installed.

R. Other code compliance. The in-building system installation and components shall comply with all the applicable local codes, including but not limited to, Federal Communications Rules (47CFR 90.219), NEC, NFPA, IBC, TIA/EIA etc.

PART 3 EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on wall as indicated on the drawings.
1. Install seismic bracing. Comply with requirements in Division 26 Section "Vibration Controls for Electrical Systems."

C. Control Relays
1. Control relays shall be installed to meet NFPA requirements. This shall include but not limited to control relays that actuate smoke and/or fire dampers and motors associated with smoke exhaust/removal systems.
   a. The maximum distance from the fire alarm control relay to the motor controller or smoke/fire damper shall be 3-ft.

D. Smoke- or Heat-Detector Spacing:
1. The fire alarm devices shown on the plans and details are diagrammatic in nature and are to establish the basis for bidding. The certified contractor shall install all devices in compliance with NFPA, National, Local codes as applicable to this project.
2. During installation the certified contractor shall review the design layout and adjust the fire alarm system using, but not limited to, the following guidelines:
   a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.

b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
c. Not less than 4 inches (100 mm) from a side wall to the near edge.
d. For exposed solid-joist construction, mount detectors on the bottom of joists unless the depth of the beams creates a pocket as defined by NFPA.
e. Refer to the latest edition of the NFPA for mounting of detectors where there is no gypsum board or acoustical tile (drop) ceilings to mount detectors on. Follow NPFA requirements for mounting height.
f. Review all structural beam depths, spacing and structural ceilings prior to installing conduits and detectors.
g. On smooth ceiling, install not more than 30 feet (9 m) apart in any direction.
h. Wall-Mounted Smoke Detectors: Not less than 4 inches (100 mm), but not more than 12 inches (300 mm), below the ceiling.
i. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to the appropriate Appendix in NFPA 72.
j. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
k. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

E. Smoke detector: Mount photoelectric smoke detector within 15’ of the central FACP and each external power supply.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Each duct detector installation shall have a hinged or latched duct access panel, 12x12 inches minimum, for sampling tube inspection and cleaning. Indicate airflow direction on the duct, adjacent to the detector.
1. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
2. Install sampling tubes so they extend the full width of the duct.

G. Manual Pull Stations: Mount semi-flush in recessed back boxes. Mount 48” AFF to top of device.
1. Coordinate for installation of devices required by code to be within 5-ft of exit doors.
a. Method of installing fire alarm cables through mullions of curtain wall systems.
1) Submit to the Engineer and Engineer for approval installation drawings showing methods to be used for routing of cables and device mounting.

H. Remote Status and Alarm Indicators: Install near each smoke detector that is not readily visible from normal viewing position. Indicators shall be installed in individual boxes and not be installed in multi-gang boxes.

I. Audible Alarm-Indicating Devices: Install 80” AFF to device bottom unless noted otherwise on the drawings.

J. Visible Alarm-Indicating Devices: Install 80” AFF to device bottom unless noted otherwise on the drawings.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

L. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

M. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

N. Digital dialer: Provide two (2) data outlet jacks compatible with the digital dialer, including data cabling as specified in these specifications (Category 5e minimum rating). Connect to the local floor telecommunications equipment as specified in these specifications. Install in ½” conduit minimum from outlet jacks to telecommunications equipment.

O. Smoke Detector Protection: Unless suitable protected against dust, paint, etc., spot type smoke detectors shall not be installed until the final construction clean-up has been completed. In the event of contamination during construction, the detectors must be replaced.

P. Detector Identification: Identification of individual detectors is required. Assign each a unique number as follows, in sequence starting at the FACP: (Addressable Loop#-- Device#) Put on the as-built plans, and also permanently mount on each detector's base so that it's readable standing on the floor below without having to remove the smoke detector. Exception: for detectors with housings (i.e., air duct, projected beam, air sampling, flame), apply the identification to a suitable location on exterior of their housing.

Q. Fire Alarm System notification circuits, an end-of-line (EOL) resistor should be located as follows:
1. In a location that is accessible to fire alarm maintenance personnel.
2. In an area where maintenance or testing at the EOL resistor location will not be disruptive to the normal use of the facility.
3. In an area that is not easily accessible to the normal building occupants (objective is to avoid accidental or malicious damage by building occupants).
4. In an area that is no higher than 9 ft of lower than 7 ft from the floor level.
5. Not located in a stairway or bathroom location.

R. The branch circuit breaker(s) supplying any circuit for Fire Alarm system equipment must be physically protected by panelboard lock or handle lock and must be identified with a 1/4" permanent red dot applied to handle or exposed body area.

S. A floor plan diagram with device identifiers shall be framed under glass and mounted near the main Fire Alarm Control Panel.

3.02 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Alarm-initiating connection to activate emergency lighting control.
4. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
5. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
6. Supervisory connections at fire-pump engine control panel.

3.03 WIRING INSTALLATION

A. Installer Qualifications: All persons terminating wiring, installing fire alarm system devices and /or programming the fire alarm systems shall meet the following minimum requirements:
1. Trained and certified by manufacturer in fire-alarm system design on the specific fire alarm system being installed on this project.
a. The factory training and certification must have occurred within the most recent 24 months. The manufacturer must sign the certification certifying the installer's compliance with their requirements.
b. Copies of the certification must be part of the Contractor's submittal to the Engineer prior to installation.
c. The submittal will not be approved without this certification.

2. In addition to the requirement for factory certification the person preparing the shop drawings shall be a NICET-certified fire-alarm technician, Level III minimum.

B. Wiring Method: Install wiring in metal raceway according to Division 26 Section “Raceways and Boxes for Electrical Systems.” Conceal raceway except in unfinished spaces and as indicated.
   1. Coordinate with the general contractor for installation of devices required by code to be within 5-ft of exit doors.
      a. Method of installing fire alarm cables through mullions of curtain wall systems.
         1) Submit to the Engineer for approval installation drawings showing methods to be used for routing of cables and device mounting.
   2. All Class A SLC loop circuits, as required herein, shall have the supply and return ‘loop’ cables installed in separate raceways to insure survivability except as noted herein.
      a. On multi-story buildings each floor shall have a dedicated Class A SLC loop.
      b. Minimum separation distance between the Class A SLC supply and return raceways/cables shall be the corridor width, less 1-ft., for the floor being served by the Class A SLC loop.
         1) Exception: The supply and return Class A loop cables may occupy the same raceway from the junction box where the SLC initiating device is mounted for a maximum distance of 6-ft. where they shall enter into a common junction box where they shall be installed in separate raceways to the next device on the loop, fire alarm terminal cabinet or fire alarm control panel.
      c. As an option on multi-story buildings, the Class A SLC supply and return raceways may be installed so that the Class A SLC loop cables terminate in fire alarm terminal cabinets located at opposite ends of the floor being served by a Class A SLC loop. From the terminal cabinets on each floor the supply and return loop cables shall be installed in raceways containing only SLC cables and shall be routed to the next fire alarm terminal cabinet on a lower floor or directly back to the fire alarm control panel.
      d. The supply and return Class A SLC loop cables/raceways shall be kept separated back to within 10-ft. from where they enter the fire alarm control panel.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the manufacturer.
   1. All wiring and splices shall be made using terminal blocks. Crimp type connectors or ‘wire nuts’ connectors are prohibited.
   2. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type.
   3. All terminal blocks shall be securely fastened in place using screws. Adhesive tape or glue will not be acceptable.
   4. Run fire alarm system wiring in dedicated raceway system containing only fire alarm system wiring.
   5. Install conductors parallel with or at right angles to sides and back of the enclosure.
   6. Bundle, lace, and train conductors to terminal points with no excess.
   7. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks.
   8. All doors of all enclosures shall contain a green insulated #12 copper conductor bonding the enclosure to the door. This shall not impede opening of the door to 180 degrees.
   9. Mark each terminal according to the system’s wiring diagrams.
   10. Make all connections with approved crimp-on terminal spade lugs, screw terminal blocks, or plug connectors.
   11. Label all wires at all termination points.
   12. Label inside of enclosure with 120 VAC source panel board and circuit number.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
   1. All system wiring shall be labeled at each termination point or splice.

B. Identify each enclosure with an engraved, red, laminated, phenolic-resin nameplate with lettering not less than 1 inch (25 mm) high. Identify individual components and modules within cabinets with permanent labels.

C. Install Instructions frame in a location visible from the FACP.

D. Label Central FACP with engraved label indicating panel location, panel name, and circuit number of power source to FACP.

E. It is understood that the room names and numbers shown on the contract document may change prior to the final acceptance of the building by the Owner.
   1. The installing contractor shall coordinate with the Owner the final room names and numbers for the entire building. This shall occur prior to the final Engineer’s acceptance testing.
   2. The FACP programming and subsequent display readouts shall indicate these room names, numbers and identical device addresses in order as follows:
      a. Device type.
      b. Equipment or unit number associated with the device whenever applicable.
      c. Location by room number.
      d. Device address number.

3.05 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground the enclosure doors using a green insulated #12 grounding conductor attached to the enclosure housing and the door. Install so that the door is free to swing open 180- degrees.

C. The Fire Alarm Control Panel shall be grounded to the AC supply source with an insulated equipment grounding conductor installed and routed in the same raceway with the AC branch circuit conductors feeding the Fire Alarm Control Panel.

3.06 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by the Engineer of Record.

B. Tests and inspections.
   1. Manufacturer's Field Service: The trained and certified person who terminates and programs the system shall be required to perform all field testing as described within these specifications.

C. Contractor/Manufacturer Representative Tests and Inspections:
   1. Visual Inspection: Conduct visual inspection prior to testing.
      a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
      b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
   2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
   4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
   5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
   6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. The engineer shall then be informed by written notification that the system is complete per plans and specifications that the 100% system test was completed and is ready for the Engineer's acceptance test.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. The Contractor shall notify the Engineer two (2) weeks in advance to schedule the Engineer's acceptance test of the completed system.

H. Engineer of Record Test and Inspections:
   1. The Engineer, in the presence of the contractor and an authorized factory-trained representative of the manufacturer who terminated and programmed the fire alarm system, shall perform an acceptance test to verify compliance with the plans, specifications and applicable codes.
   2. The contractor shall assist the engineer with the test.
   3. The test shall be directed and controlled by the Engineer.
   4. The contractor shall provide two-way radios, ladders and any other materials needed to test the system (smoke candles, approved test smoke, etc.).

I. After the Engineers acceptance test has been successfully completed and all deficiencies have been corrected, conduct a system test at final inspection as directed by State Construction Office representative. The installing contractor shall then provide specific documentation for the fire alarm system. This documentation shall include but is not limited to the following:
   1. System Status and Program Printout.
   2. System Operation Matrix.
   3. As-Built Drawings.
   4. Two Bound Copies of General System Information for the Owner.
   5. For buildings with a smoke control or smoke purge system, an HVAC balance report in the smoke control/purge mode.

J. After testing and correction of deficiencies have been completed the contractor shall provide site specified FACP programming on a diskette or CD as appropriate for review. This process shall be repeated until there are no further errors or corrections to the database.

3.07 FINAL DOCUMENTATION

A. After all system corrections have been made provide to the engineer the following documentation.
   1. Riser diagram(s) showing all fire alarm panels, power booster panels, fire alarm devices and terminal boxes. The diagram shall represent how the devices are connected to the fire alarm system and shall be suitable for trouble shooting the fire alarm system connections.
   2. Documentation shall be provided in CAD file format compatible with the engineer's CAD files for the project.
   3. The contractor shall make all corrections to the file(s) as directed by the engineer.

3.08 ACCESS

A. Access doors in walls, chases, or above inaccessible ceilings shall be provided as specified under Division 08 - Access Doors and Panels unless otherwise indicated. Access doors shall provide access for service, repair, and/or maintenance of valves, unions, fire/smoke dampers, control dampers, smoke detectors, fans, coils, reheat coils, VAV boxes, volume dampers or other equipment requiring access, which is in walls or chases, or above an inaccessible ceiling. Access doors used in fire rated construction must have UL label. During Coordination Drawing preparation, Contractor shall review architectural reflected ceiling plans for areas with inaccessible ceilings; preference shall be given to avoiding layout of systems and equipment which will require access space over inaccessible ceilings as much as possible to avoid need for access panels. If panels are unavoidable then Contractor shall clearly locate access panels during Co-

ordination Drawings preparation for review by Architect. Access doors shall be of sufficient size to allow for total maintenance by service personnel on ladder with serviceable items within arm's length.

3.09 GUARANTEE

A. All wiring, etc., shall be in strict accordance with the local Electrical Code requirements and shall have the written approval of all public authorities having jurisdiction. The Contractor shall guarantee all equipment and wiring free from inherent mechanical and electrical defects for a period of one (1) year from date of installation. The final connection between the equipment and wiring system and all programming shall be made under the direct supervision of a qualified technical representative of the manufacturer. All products of combustion detectors shall have sensitivities set by Factory Trained Technician, and results submitted to the Engineer.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

3.11 TRAINING

A. Training shall cover the following topics at a minimum:
   1. Preventative maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
   2. Overall system concepts, capabilities, and functions. Training shall be in-depth, so that the owner shall be able to add or delete devices to the system and to take any device out of service and return any device to service without need for Manufacturer's approval.
   3. Explanation of all control functions, including training to program and operate the system software.
   4. Methods and means of troubleshooting and replacement of all field wiring and devices.
   5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry and interconnections.
   6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided on 3 ½ inch floppy disk or CD and shall be left with the Owner at the completion of training for the Owner's use in the future.

PART 4 NFPA FORMS

4.01 FIRE ALARM SYSTEM CERTIFICATION OF COMPLETION.

A. Complete the latest revised NFPA 72-2013, Figure 4.5.2.1, "Record of Completion" Form.
   1. On the form, place the installer's name and NICET number or factory authorized certification number of installing technician who is responsible for certifying the installation of the fire alarm system.

B. Submit to Engineer for review prior to Engineer's scheduled acceptance testing.

END OF SECTION

SECTION 31 10 00 - SITE CLEARING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Removing existing vegetation.
   2. Clearing and grubbing (if needed).
   3. Stripping and stockpiling topsoil (if needed).
   4. Removing above- and below-grade site improvements.
   5. Disconnecting, capping or sealing, removing site utilities, and abandoning site utilities in place.
   6. Temporary erosion- and sedimentation-control measures.

1.2 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated on plans.

F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.3 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.4 SUBMITTALS

A. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.5 QUALITY ASSURANCE

A. Pre-installation Conference: Conduct conference at the Project site.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Utility Locator Service: Notify “North Carolina OneCall (811)” for area where Project is located before site clearing.

C. The Contractor shall be responsible for locating underground utilities prior to commencing work and / or excavation. If necessary, the construction manager may obtain the services of a commercial utilities locator and/or various utility companies who may have lines inside the area. In addition, Contractors shall contact the Owner's Representative at least five days prior to excavation. The Contractor will be responsible for utility interruptions caused by construction operations including excavations

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place and erosion control permit is obtained and posted at job-site.

E. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on- site.

PART 3 EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Install temporary construction fencing per Section 01 “Temporary Facilities and Controls”.

C. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Wrap a 1-inch blue vinyl tie tape flag around each tree trunk at 54 inches above the ground.

D. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of the Wake County and NCDENR.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.

1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.

1. Coordinate with Owner prior to shutting off any utilities.
2. Arrange with utility companies to shut off indicated utilities.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Owner, and Engineer not less than (72) hours in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Engineer’s written permission.

E. Excavate for and remove underground utilities indicated to be removed.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
   3. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to a minimum depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and non-soil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
   1. Limit height of topsoil stockpiles to 72 inches.
   2. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
   3. Stockpile surplus topsoil to allow for re-spreading deeper topsoil.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement and concrete to remain before removing adjacent existing pavement or concrete. Saw-cut faces vertically.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION

SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. North Carolina Department of Transportation and City of Raleigh Standard Specifications and Details where applicable.

1.2 SUMMARY

A. Section Includes:

1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
2. Excavating and backfilling for structures.
3. Subbase course for concrete walks and pavements.
4. Subbase course and base course for asphalt paving.
5. Subsurface drainage backfill for walls and trenches.
6. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Sections:

1. Division 01 Section "Construction Progress Documentation” for recording pre-excavation and earth moving progress.
2. Division 01 Section "Temporary Facilities and Controls" for temporary controls, utilities, and support facilities; also for temporary site fencing if not in another Section.
3. Division 31 Section "Site Clearing" for site stripping, grubbing, stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
4. Division 31 Section “Erosion and Sedimentation Control”.
5. Division 33 Section “Storm Utility Drainage Piping”.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices and quantity allowances for earth moving specified in Division 01 Section "Unit Prices".

B. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials for that condition.

1. 24 inches outside of concrete forms other than at footings.
2. 12 inches outside of concrete forms at footings.
3. 6 inches outside of minimum required dimensions of concrete cast against grade.
4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
5. 6 inches beneath bottom of concrete slabs-on-grade.
6. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Design Subgrade: Final subgrade elevation shown on site grading plan.

F. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

G. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below design subgrade elevations or beyond indicated lines and dimensions as directed by Engineer or Owner's Testing Agency. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.

2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.

3. Unauthorized Excavation: Excavation below design subgrade elevations or beyond indicated lines and dimensions without direction by Engineer or Owner's Testing Agency. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.

H. Fill: Soil materials used to raise existing grades.

I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. yd. for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:

1. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted Caterpillar 330 (or equivalent) using new rock teeth.

2. Bulk Excavation: Late-model, Caterpillar D-8 (or equivalent) pulling a single-tooth ripper.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Structural Fill: Soil free of trash, refuse, frozen material, or other deleterious materials, and contains less than 3% organics. Shall be free of rock or gravel larger than allowed for fill or backfill material as specified hereinafter or as shown on the drawings.

L. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

M. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geosynthetics.

2. Lime and/or cement utilized for soil/base modification.

3. ABC stone

4. Detector warning tapes.

B. Material Test Reports: For each off-site soil material proposed for fill and backfill as follows:

5. Classification according to ASTM D 2487 or method approved by Owner Representative.

6. Laboratory compaction curve according to ASTM D 698 or method approved by Owner Representative.

C. Blasting plan approved by authorities having jurisdiction and only if Owner pre-approves of blasting.

D. Seismic survey report from seismic survey agency.

E. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

1.6 QUALITY ASSURANCE

A. Blasting: Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:

1. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.

2. Seismographic monitoring during blasting operations.

B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:

1. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.

2. Seismographic monitoring during blasting operations.

C. Owner’s Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

D. Pre-excavation Conference: Conduct conference at the Project Site prior to commencement of site grading.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, parking lots, access drives, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Owner.

C. Utility Locator Service: Notify “North Carolina OneCall (811)” for area where Project is located before beginning earth moving operations.

D. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Division 31 Sections "Site Clearing" and “Erosion and Sedimentation Control” are in place.

E. Do not commence earth moving operations until a Town of Wendell Permit and NCDEMLR Erosion Control Plan Letter of Approval are obtained and posted at the project site.

F. Do not commence earth moving operations until plant-protection measures shown on the Construction Drawings are in place.

G. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.

2. Parking vehicles or equipment.

3. Foot traffic.

4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

H. Do not direct vehicle or equipment exhaust towards protection zones.

I. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Unified Soil Classification System (USCS) Groups SM, SC, SW, SP, ML, and CL according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, greater than 3% organic material, and other deleterious matter; have a standard Proctor maximum dry density of at least 90 pounds per cubic foot (pcf). USCS groups CH and MH found at the project site can be used, provided the moisture content can be controlled, but should not be placed within 2 feet of final subgrade elevations.

1. Compact to not less than 95% of the standard Proctor maximum below 12” and not less than 98% of the standard Proctor maximum for the last 12”.

C. Unsatisfactory (or Unsuitable) Soils: Soils not meeting Satisfactory Soils as described in 2.1.B.

1. On-site borrow materials with natural moisture contents at time of excavation below or up to 10 percent wet of the soil’s optimum moisture content shall not be classified as unsatisfactory if the material otherwise meets the material requirements for satisfactory materials. The contractor shall wet or dry these materials to the acceptable moisture range, chemical dry, or replace with off-site borrow at no additional cost to the Owner
2. On-site borrow materials with moisture contents more than 10 percent wet of the soil’s optimum moisture content may be considered unsatisfactory. If unsatisfactory soils are found, a meeting with owner and owners testing agency will be required prior to hauling off material.
3. Additional materials deemed unsatisfactory or unsuitable by Owner’s Representative.

D. Base Course: Aggregate meeting the ABC stone requirements specified in section 1005-3 and 1005-4 of the North Carolina Department of Transportation Standard Specifications for Roads and Structures, Current Edition.

E. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

F. Structural Fill: Same as Satisfactory Soils.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C 33; fine aggregate.

K. Topsoil: Due to previous project work on campus, there is a current stockpile of topsoil onsite. Based on recommendations from the current Project Representatives onsite it is believed that the topsoil needed for this project is stockpiled onsite.

2.2 GEOTEXTILES

A. Subsurface Drainage / Separation Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Grab Tensile Strength: 205 lb; ASTM D 4632.
2. Grab Tensile Elongation: 50%; ASTM D 4632.
3. Trapezoidal Tear Strength: 80 lb; ASTM D 4533.
4. CBR Puncture Strength: 500 lb; ASTM D 6241.
5. Apparent Opening Size: No. 80 sieve, maximum; ASTM D 4751.
6. Permittivity: 0.2 per second, minimum; ASTM D 4491.
7. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

B. Stabilization Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Grab Tensile Strength: 247 lbf; ASTM D 4632.
2. Sewn Seam Strength: 222 lbf; ASTM D 4632.
3. Tear Strength: 90 lbf; ASTM D 4533.
4. Puncture Strength: 90 lbf; ASTM D 4833.
5. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
6. Permittivity: 0.02 per second, minimum; ASTM D 4491.
7. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

C. Detectable Tracer Wire: In accordance with NC General Statute 87-121 (g), Wake County requires a #12 solid bare copper wire is to be installed with gravity sewer mains and services, storm drainage systems, reuse mains and services, and any nonmetallic water service tubing. It is not required for DIP water mains or copper water services.

PART 3 - EXECUTION

3.1 PREPARATION

A. Follow Construction Sequence provided on Drawings.

B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

C. Protect and maintain erosion and sedimentation controls during earth moving operations.

D. Remove from site, material encountered in grading operations that does not meet the definition of Satisfactory Soils (2.1.B). Dispose of in manner satisfactory to Owner and local governing agencies. Backfill areas with layers of satisfactory material and compact as specified herein. Materials encountered within the top 6 inches of existing site elevations (prior to stripping) are the responsibility of the Contractor at no additional cost to the Owner (i.e. allowances only apply to depths below top 6 inches of existing site elevations, prior to stripping).

E. Prior to placing fill in low areas, such as previously existing creeks, or ponds, perform following procedures:

1. Drain water out by gravity with ditch having flow line lower than lowest elevation in low area. If drainage cannot be performed by gravity ditch, use adequate pump to obtain the same results.
2. After drainage of low area is complete, remove muck, mud, debris, and other unsatisfactory material by using acceptable equipment and methods that will keep natural soils underlying low area dry and undisturbed. Materials encountered within the top 6 inches of existing site elevations (prior to stripping) are the responsibility of the Contractor at no additional cost to the Owner (i.e. allowances only apply to depths below top 6 inches of existing site elevations, prior to stripping).
3. All muck, mud, and other materials removed from low areas shall be dried on-site by spreading in thin layers for observation. Material shall be inspected and, if found to be satisfactory for use as fill material, shall be incorporated into lowest elevation of site filling operation, but not within 5’-0” of perimeter of paving or retaining wall subgrade. If, after observation, material is found to be unsatisfactory, it shall be removed from site.

F. After topsoil stripping, notify Owner’s Testing Agency. Proof-roll exposed subgrades in fill areas with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 20 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or frozen subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer or Owner’s Testing Agency, and replace with compacted backfill or fill as directed. Materials encountered within the top 6 inches of existing site elevations (prior to stripping) are the responsibility of the Contractor at no additional cost to the Owner (i.e. allowances only apply to depths below top 6 inches of existing site elevations, prior to stripping).

G. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Design:

1. Designate and obtain the services of a qualified dewatering specialist to provide dewatering plan as may be necessary to complete the Work.
2. Contractor shall be responsible for the accuracy of the drawings, design data, and operational records required.
3. Contractor shall be responsible for the design, installation, operation, maintenance, and any failure of any component of the system.

B. Damages:

1. Contractor shall be responsible for an shall repair any damage to work in place, other contractor's equipment, utilities, residences, highways, roads, railroads, private and municipal well systems, adjacent structures, natural resources, habitat, existing wells, and the excavation. Contractor responsibility shall also include, damage to the bottom due to heave and including but not limited to, removal and pumping out of the excavated area that may result from Contractor's negligence, inadequate or improper design and operation of the dewatering system, and any mechanical or electrical failure of the dewatering system.
2. Remove subgrade materials rendered unsatisfactory by excessive wetting and replace with approved backfill material at no additional cost to the Owner.

C. Maintaining Excavation in Dewatering Condition

1. Dewatering shall be a continuous operation. Interruptions due to power outages or any other reason will be permitted.
2. Continuously maintain excavation in a dry condition with positive dewatering methods during preparation of subgrade, installation of pipe, and construction of structures until the critical period of construction or backfill is completed to prevent damage of subgrade support, piping, structure, side slopes, or adjacent facilities from flotation or other hydrostatic pressure imbalance.
3. Provide standby equipment on site, installed, wired, and available for immediate operation if required to maintain dewatering on a continuous basis in the vent any part of the system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, perform such work as may be required to restore damaged structures and foundation soils at no additional cost to Owner.
4. System maintenance shall include but not be limited to 24-hour supervision by personnel skilled in the operation, maintenance, and replacement of system components and any other work required to maintain excavation in dewatered condition.

D. System Removal: Upon completion of the work, remove dewatering equipment from the site, including related temporary electrical service.

E. Wells shall be removed or cut off a minimum of 3 feet below final ground surface, capped and abandoned in accordance with regulations by agencies having jurisdiction.

3.3 EXPLOSIVES

A. Explosives: Obtain written permission from authorities having jurisdiction including Owner before bringing explosives to Project site or using explosives on Project site.

1. Perform blasting without damaging adjacent structures, property, or site improvements.
2. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to design subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include pavements, underground structures, utilities, obstructions, and other items indicated to be removed; together with soil, boulders, and rock. No changes in the

Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or unsuitable soils to subgrade elevation.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory materials. Contractor will be paid for disposal and replacement of unsatisfactory materials encountered at depths greater than 6 inches below the existing ground surface elevation, prior to stripping.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
   b. 24 inches outside of concrete forms other than at footings. 12 inches outside of concrete forms at footings.
   c. 6 inches outside of minimum required dimensions of concrete cast against grade.
   d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
   e. 6 inches beneath bottom of concrete slabs-on-grade subbase materials.
   f. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

B. Unsatisfactory Soils: Volume of soils not meeting the definition of Satisfactory Soils (2.1.B), or determined by the Owner's Testing Agency to be unstable or unsuitable for subgrade support, measured in original position, and replaced with satisfactory structural fill/subgrade/foundation material that meets the allowable design bearing pressure, compaction requirements, and settlement limitations specified in the geotechnical report and construction documents for the site and structure. Unsatisfactory soils shall not be removed until approved and cross-sectioned by Owner's Testing Agency. Changes in the Contract Sum or the Contract Time will be in accordance with Allowances and Unit Prices provisions for removal and replacement of unsuitable soils. No changes in the Contract Sum or the Contract Time if unsatisfactory materials are encountered within 6 inches below the existing ground surface elevation, prior to stripping.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   2. Deep Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of pile cap before deep foundations are placed. After foundations have been installed, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete caps.
   3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:
   1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
   2. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit.

1. Clearance: 6 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
4. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or unsuitable soils to trench bottom.

E. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree and Plant Protection."

3.8 SUBGRADE EVALUATION

A. Notify Owner’s Testing Agency when excavations have reached required subgrade.

B. If Owner’s Testing Agency determines that Unsatisfactory Soils (3.4.B) are present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll final subgrade below pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 20 tons to identify soft pockets and areas of excess yielding. Do not proof- roll wet or frozen subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer or Owner’s Testing Agency, and replace with compacted backfill or fill as directed.

D. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation, removal of obstructions, or Unsatisfactory soils to subgrade elevation.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavations as directed by Engineer.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Stockpile soil materials away from edge of excavations.
   2. Place silt fence approximately 3-ft from edge of stockpile.
   3. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:
   1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
   2. Surveying locations of underground utilities for Record Documents.
   3. Testing and inspecting underground utilities.
   4. Removing concrete formwork.
   5. Removing trash and debris.
   6. Removing temporary shoring and bracing, and sheeting.
   7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil.

D. Trenches under Roadways: After installing and testing piping or conduit less than 30 inches below surface of roadways, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."

E. Backfill voids with satisfactory soil compacted in accordance with specifications provided herein while removing shoring and bracing.

F. Place and compact initial backfill of subbase material and satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
   1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. All underground piping and utilities (both metallic and non-metallic), except lawn irrigation lines, shall have two stages of identification and/or warning by a combination of non-detectable and detectable warning tapes.

I. Install warning tape (detectable warning tape) directly on top of the pipeline and permanently secured to the pipeline at 10’ intervals.

J. Install identification tape (non-detectable warning tape) approximately 18” to 30” above the service pipe, but a minimum of 10” and a maximum of 24” below finished grade.

K. Install tracer wire to bottom of pipe taped at a maximum of 10’ intervals. An insulated copper tracer wire or other approved conductor shall be installed along the length of the pipe to all nonmetallic piping, including irrigation lines, and metallic pipe with compression gasket fittings

installed underground. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at the end of the nonmetallic piping. The tracer wire size shall be copper single-conductor 10AWG minimum and the insulation type suitable for direct burial with type “UF” (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box or manhole.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers using satisfactory fill (or structural fill) to required elevations.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 3 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. On-site borrow materials with natural moisture contents below or up to 10 percent wet of the soil’s optimum moisture content shall not be classified as unsatisfactory if the material otherwise meets the material requirements for satisfactory materials. The contractor shall wet or dry these materials to the acceptable moisture range, chemical dry, or replace with off-site borrow at no additional cost to the Owner.

3. On-site borrow materials with moisture content more than 10 percent wet of the soil’s optimum moisture content may be considered unsatisfactory.

4. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 3 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact as follows:

Location	Percent of Maximum Laboratory Density ASTM D698
Subgrade and Fill below Structures and Pavement (top 12 inches)	98
Subgrade and Fill below Structures and Pavement (below top 12 inches)	95
Subgrade & Fill in All other Areas	90

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.

2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

3.17 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Division 33 Section "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 95 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.

C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 95 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.
2. Place and compact impervious fill over drainage backfill in 6-inch- thick compacted layers to final subgrade.

3.18 BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place base course on subgrades approved by the Owner’s Testing Agency free of mud, frost, snow, or ice.

B. On prepared subgrade, place base course under pavements and walks as follows:

1. Place base course material over subgrade under hot-mix asphalt pavement.
2. Shape base course to required crown elevations and cross-slope grades.
3. Place base course 10 inches or less in compacted thickness in a single layer.
4. Place base course that exceeds 10 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 4 inches thick.
5. Compact base course at moisture content within +/- 2% of optimum moisture to required grades, lines, cross sections, and thickness to not less than 98 percent of maximum dry unit weight according to ASTMD1556 as modified by NCDOT.

C. Pavement Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each base layer to not less than 98 percent of maximum dry unit weight according to the standard Proctor maximum dry density (ASTM D698).

3.19 FIELD QUALITY CONTROL

A. Owner’s Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to evaluate and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved: At subgrade and at each compacted fill and backfill layer, at least one test for every 2500 sq. ft. or less of paved area, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

D. Maintain subgrades to receive base course stone within compaction and moisture requirements continuously until stone is placed.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Transport surplus satisfactory soil and topsoil to designated storage areas on Owner's property or remove from site and legally dispose as directed by Engineer. Stockpile or spread soil as directed by Engineer.

1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION

SECTION 31 23 17 – TRENCHING

PART 1 GENERAL

1.1 GENERAL NOTES

A. Prior to beginning Work, Contractor to request a field inspection with the Owner and Engineer for inspection before project start and before project acceptance.

B. Trenches for underground piping, where necessary shall be excavated to the required depth and bell holes shall be provided where necessary to insure uniform bearing. Trench excavation lines shall provide sufficient clearance for proper execution of underground work.

C. Trenches shall be open cut from the surface. Irregularities at bottom of trench, or where excavation is below required depth shall be refilled to required grade with compacted soil, or flowable fill at direction of onsite geotechnical engineer.

D. The Contractor shall be held responsible for the sufficiency of sheeting and bracing and for all damages to property or injury to persons resulting from improper quality, strength, placing and maintenance of trench shoring, sheeting or bracing.

E. Existing utility lines to be retained that are shown on construction drawings or locations of which are made known to the Contractor prior to excavation operations, shall be protected from damage during excavation and backfilling, and if damaged shall be repaired by Contractor, at own expense.

F. Existing utility lines found during excavations that were not shown on construction drawings or made known to Contractor prior to excavation shall be protected and remain uninterrupted until approval by Owner or Engineer to proceed.

G. The Contractor shall be responsible for providing and maintaining a pedestrian and traffic control plan in accordance with Owner standards.

H. All underground utilities encountered during the projects construction shall be located by a Professional Land Surveyor licensed in North Carolina.

1.2 DEFINITIONS

A. Standard Specifications: When referenced in this section, shall mean Department of Transportation Standard Specifications For Roads And Structures, January 2018. Parts of these Standard Specifications that are specifically referenced shall become part of this section as though stated herein in full. In case of a discrepancy between the requirements of the Standard Specifications and the requirements stated herein, the requirements herein shall prevail.

1.3 SUMMARY

A. Section Includes:
   1. Excavating trenches for utilities from 5 feet outside any building to terminating connection.
   2. Compacted fill from top of utility bedding to finished grade.
   3. Backfilling and compaction.

1.4 SUBMITTALS

A. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.

B. Product Data: Geotextile fabric indicating fabric and construction.

C. Materials Source: Name of imported fill materials suppliers.

1.5 QUALITY ASSURANCE

A. Use this Article to specify compliance with overall reference standards affecting products and installation.

B. Perform Work according to NCDOT, City of Raleigh, and Wake County standards.

C. Prepare excavation protection plan under direct supervision of professional engineer experienced in design of this Work and licensed in State of North Carolina.

1.6 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.7 COORDINATION

A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Subsoil Fill: Type as specified in Standard Specifications.

B. Structural Fill: Type as specified in Standard Specifications.

C. Granular Fill: Type as specified in Standard Specifications.

D. Concrete:
   1. Lean concrete.

2.2 ACCESSORIES

A. Geotextile Fabric: Non-biodegradable, non-woven. Use NCDOT standard for fabric application and type by use.

PART 3 EXECUTION

3.1 LINES AND GRADES

A. Lay pipes to lines and grades indicated.
   1. Engineer may make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.2 PREPARATION

A. Call local utility line information service at 811 not less than three working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum locations.

C. Protect plant life, lawns, and other features remaining as portion of final landscaping.

D. Protect benchmarks, existing structures, trees, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

E. Maintain and protect above and below grade utilities indicated to remain.

F. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.3 TRENCHING

A. Excavate subsoil required for utilities.

B. Remove lumped subsoil, boulders, and rock over 6 inches.

C. Perform excavation within 24 inches of existing utility service according to utility’s requirements.

D. Do not advance open trench more than 200 feet ahead of installed pipe.

E. Cut trenches sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with Work, dewater in accordance with Section 31 23 19.

F. Excavate bottom of trenches to a maximum of 2 feet past outside diameter dimensions or outside of concrete cradle.

G. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and pipe.

H. When Project conditions permit, slope side walls of excavation starting 24 inches above top of pipe. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this Section.

I. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by onsite Owner's Testing Agency until suitable material is encountered.

J. Cut out soft areas of subgrade not capable of compaction in place. Backfill with flowable fill or Owner's Testing Agency approved fill and compact to density equal to or greater than requirements for subsequent backfill material.

K. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.

L. Correct areas over excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Engineer.

M. Remove excess subsoil not intended for reuse, from Site.

N. Stockpile excavated material in area designated on Site according to Section 31 25 00.

3.4 SHEETING AND SHORING

A. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

B. Support trenches excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation or at direction of onsite geotechnical engineer.

C. Design sheeting and shoring to be removed at completion of excavation Work.

D. Repair damage caused by failure of sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.5 BACKFILLING

A. Backfill trenches to contours and elevations with Satisfactory Soils per Section 312000.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

C. Place fill material in continuous layers and compact to 95 percent of the material's standard Proctor maximum dry density ASTM D698), except in the top 12 inches where this shall be increased to 98 percent.

D. Protect open trench to protect the public.

3.6 FIELD QUALITY CONTROL

A. Perform laboratory material tests according to ASTM D698.

B. Perform in place compaction tests according to following:
   1. Density Tests: ASTM D698.
   2. Moisture Tests: ASTM D3017.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

D. Test as required in Section 31200, "Field Quality Control".

3.7 PROTECTION OF FINISHED WORK

A. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION

SECTION 31 23 19 – DEWATERING

PART 1 GENERAL

1.1 GENERAL NOTES

A. Excavations should be kept dry at all times by means of cofferdams, trenches, sumps, pumps or other equipment or arrangements required and approved.

B. Prevent surface water from flowing into excavations, ponding on prepared subgrades and from flooding Project site and surroundings.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation and/or subsurface seepage.

D. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations or trenches. Establish and maintain temporary drainage ditches and other diversions outside excavation limits as required and approved by Owner or Engineer.

E. Do not use excavations or trenches as temporary drainage ditches.

1.2 SUMMARY

A. Section Includes:
   1. Construction site dewatering.

1.3 DEFINITIONS

A. Dewatering includes the following:
   1. Removing surface or ground water from within excavations or trenches.
   2. Disposing of removed water.

B. Surface Water Control: Removal of surface water within open excavations.

1.4 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
   1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
   2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
   3. Prevent surface water from entering excavations by grading, dikes, or other means.
   4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
   5. Remove dewatering system when no longer required for construction.

1.5 QUALITY ASSURANCE

A. Pre-installation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to dewatering including, but not limited to, the following:
      a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
      b. Proposed site clearing and excavations.

1.6 PROJECT CONDITIONS

A. Survey Work: Engage a qualified land surveyor to survey adjacent structures and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
   1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Engineer if changes in elevations occur or if any damage is evident in adjacent construction.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION

A. Conduct additional borings and investigations to supplement subsurface investigations identified as required to complete dewatering system design.

B. Call Local Utility Line Information service at 811 not less than three working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
   1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
   2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Monitor dewatering systems continuously.

E. Promptly repair damages to adjacent facilities caused by dewatering.

F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 31 25 00 during dewatering operations.

3.3 INSTALLATION

A. Contractor shall furnish, install, operate, and maintain any pumping equipment, etc. needed for removal of water from various parts of the site at no additional cost to the Owner.

B. Work shall be in accordance with NCDOT standards.

3.4 FIELD QUALITY CONTROL

A. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

END OF SECTION

SECTION 31 23 24 - FLOWABLE FILL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Flowable fill for:
      a. Structure backfill.
      b. Utility bedding.
      c. Utility backfill.
      d. Filling abandoned utilities.
      e. Concrete Cradle.

1.2 DEFINITIONS

A. Utility: Any buried pipe, duct, conduit, manhole, tank, or cable.

B. Excavatable Flowable Fill: Lean cement concrete fill used where future excavation may be required such as fill for utility trenches, bridge abutments, and culverts.

C. Non-excavatable Flowable Fill: Lean cement concrete fill used where future excavation is not anticipated such as fill below structure foundations and filling abandoned utilities.

1.3 SUBMITTALS

A. Materials Source: Name of flowable fill materials suppliers.

B. Mix Design:
   1. Furnish flowable fill mix design for each specified strength. Furnish separate mix designs when admixtures are require for following:
      a. Flowable fill Work during hot and cold weather.
      b. Air entrained flowable fill Work.
   2. Identify design mix ingredients, proportions, properties, admixtures, and tests.
   3. Furnish test results to certify flowable fill mix design properties meet or exceed specified requirements.

C. Delivery Tickets:
   1. Furnish duplicate delivery tickets indicating actual materials delivered to Project Site.

1.4 QUALITY ASSURANCE

A. Perform Work according to State of North Carolina Department of Transportation standards.

B. Manufacturer: Company specializing in manufacturing products specified in this Section with three years' experience.
   1. Product source approved by authority having jurisdiction.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not install flowable fill during inclement weather or when ambient temperature is less than 40 degrees F.

PART 2 PRODUCTS

2.1 FLOWABLE FILL

A. Furnish materials according to State of North Carolina Department of Transportation standards.

B. Flowable Fill: Excavatable type.

C. Flowable Fill for Stormwater Control Measure cradle: Non-Excavatable Type; 750 psi minimum.

2.2 MATERIALS

A. Portland Cement: ASTM C150 Type I - Normal.

B. Fine Aggregates: ASTM C33.

C. Water: Clean and not detrimental to concrete.

2.3 ADMIXTURES

A. Furnish materials according to State of North Carolina Department of Transportation standards.

2.4 MIXES

A. Mix and deliver flowable fill according to ASTM C94/C94M, Option C.

B. Flowable Fill Design Mix:

ITEM	EXCAVATABLE	NON-EXCAVATABLE
Cement Content	75 to 100 lb/cu yd	100 to 150 lb/cu yd
Fly Ash Content	None	150 to 600 pcf
Water Content	As specified	As specified
Air Entrainment	5-35 percent	5-15 percent
28-Day Compressive Strength	Maximum 100 psi	Minimum 125 psi
Unit Mass (Wet)	80 to 110 pcf	100 to 125 pcf
Temperature, Minimum at Point of Delivery	50 degrees F	50 degrees F

C. Provide water content in design mix to produce self-leveling, flowable fill material at time of placement.

D. Design mix air entrainment and unit mass are for laboratory design mix and source quality control only.

2.5 SOURCE QUALITY CONTROL

A. Test and analyze properties of flowable fill design mix and certify results for following:
   1. Properties of hardened flowable fill design mix including:
      a. Compressive strength at 1 day, 7 days, and 28 days. Report compressive strength of each specimen and average specimen compressive strength.
      b. Unit mass for each specimen and average specimen unit mass at time of compressive strength testing.

B. Prepare delivery tickets containing following information:
   1. Project designation.
   2. Date.
   3. Time.
   4. Class and quantity of flowable fill.
   5. Actual batch proportions.
   6. Free moisture content of aggregate.
   7. Quantity of water withheld.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify excavation is complete.

B. Verify utility installation is complete and tested before placing flowable fill.

C. Verify excavation is dry and dewatering system is operating, if required.

3.2 PREPARATION

A. Support and restrain utilities to prevent movement and flotation during installation of flowable fill.

B. Protect structures and utilities from damage caused by hydraulic pressure of flowable fill before fill hardens.

C. Protect utilities to prevent intrusion of flowable fill.

3.3 INSTALLATION - FILL, BEDDING, AND BACKFILL

A. Place flowable fill by chute, pumping or other methods approved by Engineer.
   1. When required, place flowable fill under water using tremie procedure.
   2. Do not place flowable fill through flowing water.

B. Place flowable fill in lifts to prevent lateral pressures from exceeding structural capacity of structures and utilities.

C. Place flowable fill evenly on both sides of utilities to maintain alignment.

D. Place flowable fill to elevations indicated without vibration or other means of compaction.

3.4 INSTALLATION - FILLING ABANDONED UTILITIES

A. Perform work in accordance with Standard Specifications and Construction Drawings.

B. Verify pipes and conduits are not clogged and are sufficiently empty to permit gravity installation of flowable fill for entire length indicated to be filled.

C. Seal lower end of pipes and conduits by method to contain flowable fill and to vent trapped air caused by filling operations.

D. Place flowable fill using method to ensure there are no voids.
   1. Fill pipes and conduits from high end.
   2. Fill manholes, tanks, and other structures from grade level access points.

E. After filling pipes and conduits seal both ends.

3.5 FIELD QUALITY CONTROL

A. Perform testing according to ASTM C94/C94M.
   1. Take samples for tests for every 150 cu yd of flowable fill, or fraction thereof, installed each day.
   2. Sample, prepare and test four compressive strength test cylinders according to ASTM D4832. Test one specimen at 3 days, one at 7 days, and two at 28 days.
   3. Measure temperature at point of delivery when samples are prepared.

B. Defective Flowable Fill: Fill failing to meet following test requirements or fill delivered without following documentation.
   1. Test Requirements:
      a. Minimum temperature at point of delivery.
      b. Compressive strength requirements for each type of fill.
   2. Documentation: Duplicate delivery tickets.

3.6 CLEANING

A. Remove spilled and excess flowable fill from Project Site.

B. Restore facilities and Site areas damaged or contaminated by flowable fill installation to existing condition before installation.

END OF SECTION

SECTION 31 25 00 - EROSION AND SEDIMENTATION CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. This section covers work necessary for stabilization of soil to prevent erosion during and after construction and land disturbance activities. The work shall include furnishing all labor, materials, tools, and equipment to perform all work and services necessary for or incidental to the furnishing and installation, complete, of all operations in connection with erosion control as shown on drawings and as specified, in accordance with provisions of the Contract Documents, and completely coordinated with work of all other trades. The Contractor shall insure that all sedimentation features are in place prior to construction as necessary. Contractor shall remove the features as ground cover is established with approval of the Engineer and/or controlling authorities.

B. The minimum areas requiring soil erosion and sediment control measures are indicated on the Drawings. The right is reserved to modify the use, location, and quantities of soil erosion and sedimentation control measures based on activities of the Contractor and as the Engineer considers to be the best interest of the Owner.

C. Any governmental agency standard as noted below should be referenced as the latest, most recent, or current version of the referenced standard.

D. The Contractor shall implement the approved Erosion and Sediment Control plan and follow all state requirements regarding sedimentation and erosion control. Construction methods shall minimize sedimentation and erosion.

E. See additional information noted on the Drawings.

1.2 DEFINITIONS

A. NCDOT: North Carolina Department of Transportation

B. NCDEQ - DEMLR: North Carolina Department of Environmental Quality - Division of Energy, Mineral, and Land Resources.

C. Standard Erosion Control Specification: North Carolina Erosion and Sediment Control Planning and Design Manual, latest version. Available at the following location: http://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/erosion-sediment-control-planning-design-manual

1.3 GENERAL

A. All activities shall conform to the Standard Erosion Control Specification: North Carolina Erosion and Sediment Control Planning and Design Manual, latest version; the approved erosion control permit; the Specifications; and the Drawings. In the event of a conflict, the more stringent requirement shall apply.

B. The Sections of the Standard Erosion Control Specifications referenced include, but are not limited to:

Standard & Specification No	Title
6.06	Temporary Gravel Construction Entrance / Exit
6.10	Temporary Seeding
6.17	Rolled Erosion Control Products
6.20	Temporary Diversions

6.32	Temporary Slope Drains
6.51	Hardware Cloth and Gravel Inlet Protection
6.62	Sediment Fence (Silt Fence)
6.64	Skimmer Sediment Basin
6.66	Compost Sock
6.80	Construction Road Stabilization
6.83	Check Dam

C. Soil erosion stabilization and sedimentation control shall consist of the following elements:
   1. Maintenance of existing permanent or temporary storm drainage piping and channel systems, as necessary.
   2. Construction of temporary erosion control facilities such as silt fences, inlet protection, etc.
   3. Topsoil, Temporary Seeding, and Sod:
      a. Placement and maintenance of Temporary Seeding on all areas disturbed by construction, as necessary
      b. Placement of permanent topsoil, fertilizer, and sod, etc. in areas as specified on the Drawings.
   4. It is the intent that all areas in which construction activities have disturbed existing vegetation shall be temporarily seeded, as required, top soiled, and permanently sodded.

D. The Contractor shall be responsible for phasing Work in areas allocated for his / her exclusive use during this Project, including any proposed stockpile areas, to restrict sediment transport. This will include installation of any temporary erosion control devices, ditches, or other facilities that may be required to comply with NCDEQ regulations and requirements.

E. The areas set aside for the Contractor's use during the Project may be temporarily developed to provide satisfactory working, staging, and administrative areas for his / her exclusive use. Preparation of these areas shall be in accordance with other requirements contained within these Specifications and shall be done in a manner to both control all sediment transport from the project area, and to permit the area to be returned to design grades and drainage patterns upon completion of the project.

F. Upon completion of the Project, all areas that have been disturbed by the Contractor shall be stabilized by top-soiling and permanent sodding seeding as shown on the Drawings.

G. All permanent stockpiles, if any, shall be seeded with soil stabilization seed and protected by construction of two (2) rows of silt fence.

H. Sediment transport and erosion from working stockpiles shall be controlled and restricted from moving beyond the immediate stockpile area by construction of temporary silt fence, as necessary. The Contractor shall keep these temporary facilities in operational condition by regular cleaning, re-grading, and maintenance.

I. The Contractor shall maintain all elements of the Soil Erosion Stabilization and Sedimentation Control systems to be constructed during this Project for the duration of his / her activities on this Project. Formal inspections made jointly by the Contractor and the Engineer shall be conducted every week to evaluate the Contractor's conformance to the requirements of both these Specifications and NCDEQ regulations.

J. Maintenance of the Soil Erosion Stabilization and Sedimentation Control systems constructed as part of this project shall be in accordance with the Drawings and NCDEQ Standard Erosion Control Specifications.

K. Contractor shall remove all erosion control measures from the site once permit requirements for vegetation establishment have been met. All areas disturbed during the removal of erosion control measures shall be raked, stabilized, and planted per the Drawings.

1.4 SUBMITTALS

A. Submittals shall be made in accordance with the Specifications, Section 013300, “Submittal Procedures.”

B. In addition, the Contractor shall provide the following specific information:
   1. If Contractor plans to vary erosion control phasing from the Drawings, then he / she shall submit a written plan, including definition and locations of phased erosion and sediment control for areas that will be disturbed during staged construction sequences. This information shall be provided to the Engineer and Owner, for review, before commencing any Work on the Project.

1.5 QUALITY ASSURANCE

A. Perform Work according to NCDEQ-DEMLR standards.

1.6 INSPECTIONS AND RECORD KEEPING

A. The Contractor is responsible for self-inspection of sedimentation and erosion control devices throughout the life of the Work, including preparation of self-inspection reports and NPDES Self-Monitoring Reports, to make sure the approved erosion and sedimentation control plan is being followed. To simplify documentation of Self-Inspection Reports and NPDES Self-Monitoring Reports, Contractor shall use a combined form available at http://deq.nc.gov/about/divisions/energy-mineral-land-resources/erosion-sediment-control/forms

B. Contractor shall refer to Self-Inspection Reports Reporting Requirements on Drawings.

PART 2 PRODUCTS

2.1 AGGREGATE

A. Temporary Construction Entrance
   1. Furnish according to Standard Erosion Control Specification

B. Silt Fence Outlet
   1. Furnish according to Standard Erosion Control Specification

2.2 GEOTEXTILES

A. Sediment Fence Geotextile
   1. Furnish according to Standard Erosion Control Specification

B. Construction Entrance Geotextile
   1. Furnish according to Standard Erosion Control Specification

C. Rolled Erosion Control Blanket
   1. Rolled erosion control blankets shall have a minimum allowable shear stress of 1.5-lbs/ft2 and a minimum longevity of 12 months
   2. Anchoring devices for rolled erosion control blankets shall be minimum 11 gauge staples, 1-in wide, and 6-in long or 12-in minimum length wooden stakes.

2.3 TEMPORARY SLOPE DRAINS

A. Furnish according to Standard Erosion Control Specification

2.4 SKIMMER BASIN

A. Skimmer shall meet the design requirements of the drawings and the Standard Erosion Control Specifications

B. Porous baffles shall be furnished according to Standard Erosion Control Specification

2.5 SEDIMENT FENCE STEEL POSTS

A. Furnish according to Standard Erosion Control Specification

2.6 SEDIMENT FENCE FABRIC REINFORCEMENT

A. Furnish according to Standard Erosion Control Specification

2.7 COIR FIBER WATTLE

A. Coir Fiber Wattle shall meet the following specifications:
   1. 100% Coir (Coconut) Fibers
   2. Minimum Diameter 12 in.
   3. Minimum Density 3.5 lb/ft3 +/- 10%
   4. Net Material Coir Fiber
   5. Net Openings 2 in. x 2 in.
   6. Net Strength 90 lbs.
   7. Minimum Weight 2.6 lbs./ft. +/- 10%

2.8 PLANTING MATERIALS

A. Temporary Seeding and Soil Supplements:
   1. Furnish according to Standard Erosion Control Specification

B. Permanent Seeding (if used)
   1. Furnish according to Standard Erosion Control Specification

C. Sod (if used)
   1. Furnish according to Owner requirements matching the existing natural turf within the project area.

PART 3 EXECUTION

3.1 GENERAL

A. The Contractor shall install erosion and sediment control measures and maintain in accordance with the Drawings, the sequence of construction shown on the Drawings are made a part of these Contract Documents.

B. The Contractor shall install any additional measures which the Engineer or Inspector may deem necessary to comply with the Standard Erosion Control Specification general criteria or NCDEQ Erosion Control requirements, at no additional cost to the Owner.

C. The Contractor shall provide and maintain Temporary Seeding at all times.

3.2 SILT FENCE

A. Silt fence to be installed as indicated on Drawings and per the Standard Erosion Control Specification. Silt fence to be placed prior to demolition, trench installations, or other clearing activities. Silt fence may be temporarily removed and replaced to facilitate construction.

B. Maintenance shall be performed per the Standard Erosion Control Specification.

C. After ground cover has been established and approved by Engineer and NCDEQ Erosion Control Inspector, the silt fence shall be removed and disposed of in an approved off-site location at the Contractor’s expense.

3.3 SILT FENCE OUTLETS

A. Install silt fence outlets per the details shown on Drawings and per the Standard Erosion Control Specification.

B. Maintenance shall be performed per the Standard Erosion Control Specification.

C. Contractor to verify silt fence outlet placement at low points as they exist or develop. Additional silt fence outlets may be required to prevent erosion during and after construction and land disturbance activities. If additional silt fence outlets are necessary, Contractor to add additional silt fence outlets per Engineer, NCDEQ Erosion Control Inspector, or Owner direction at no additional cost to the Owner.

3.4 TEMPORARY DIVERSION DITCHES AND SLOPE DRAINS

A. Install temporary diversion ditches as shown on the drawings, details and per the Standard Erosion Control Specification.

B. Where shown on the drawings, install rolled erosion control blankets and rock check dams per the details and the Standard Erosion Control Specification.

C. Install temporary slope drains per the drawings and the Standard Erosion Control Specification where runoff from diversion ditches enters the sediment basins, as shown on the drawings.

D. Maintenance shall be performed per the Standard Erosion Control Specification.

3.5 SKIMMER BASINS

A. Install skimmer basins as shown on the drawings per the details and the Standard Erosion Control Specification.

B. Maintenance shall be performed per the Standard Erosion Control Specification.

3.6 INLET PROTECTION

A. Install Inlet Protection per the detail shown on Drawings and per the Standard Erosion Control Specification.

B. Inlet protection shall be placed at the upstream side of any pipe or structure discharging outside of the disturbed limits. See Drawings for location.

3.7 CONSTRUCTION ENTRANCE

A. Install construction entrance per the detail shown on Drawings and per the Standard Erosion Control Specification.

B. Shall be maintained in a condition to prevent tracking or direct flow of mud onto adjacent roadways.

3.8 STOCKPILES

A. Install stockpiles per the detail shown on Drawings and per the Standard Erosion Control Specification.

B. Stockpile height shall not to exceed 15 feet and side slopes shall be 2 (H) to 1 (V) or flatter.

C. Stockpile shall have a minimum double row of silt fence as shown on Drawings.

3.9 GROUND STABILIZATION

A. Contractor shall provide ground stabilization per the Standard Erosion Control Specification and in accordance with the table below:

Site Area Description	Stabilization Time Frame	Stabilization Time Frame Exceptions
Perimeter Dikes, Swakes, Ditches, and Slope	7 Days	None
High Quality Water (HQW) Zones	7 Days	None
Slopes Steeper Than 3:1	7 Days	If Slopes are 10’ or less in length and are not steeper than 2:1, 14 Days
Slopes 3:1or Flatter	14 Days	7-Days for slopes greater than 50-ft in length
All other areas with slopes flatter than 4:1	14 Days	None (except for perimeters and HQW zones)

3.10 TEMPORARY SEEDING

A. Temporary Seeding is to be placed and maintained over all disturbed areas prior to Permanent Sodding per the detail shown on Drawings and per the Standard Erosion Control Specification

B. Maintain Temporary Seeding until such time as areas are approved for permanent seeding. As a minimum, maintenance shall include the following:
   1. Fix-up and reseeding of bare areas or re-disturbed areas.
   2. Mowing for stands of grass or weeds exceeding 6 inches in height.

END OF SECTION

SECTION 31 31 16 - SOIL TREATMENT FOR TERMITE CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Chemical soil treatment.

1.02 REFERENCES

A. Title 7, United States Code, 136 through 136y - Federal Insecticide, Fungicide and Rodenticide Act; 2019.

1.03 SUBMITTALS

A. Product Data: Indicate toxicants to be used, composition by percentage, dilution schedule, intended application rate.

B. Installer qualifications.

C. Manufacturer's Application Instructions.

D. Warranty: Submit warranty and ensure that forms have been completed in Owner's name.

E. North Carolina Structural Pest Control Committee New Construction Termite Treatment Record.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing this type of work.
   1. Licensed in the State in which the Project is located.

1.05 WARRANTY

A. Provide five year installer's warranty against damage to building caused by termites.

PART 2 PRODUCTS

2.01 MATERIALS

A. Toxicant Chemical: EPA (Title 7, United States Code, 136 through 136y) approved; synthetically color dyed to permit visual identification of treated soil.

2.02 MIXES

A. Mix toxicant to manufacturer's instructions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that subgrade preparation is complete.

3.02 APPLICATION

A. Inject toxicant in accordance with manufacturer's instructions.

B. Apply toxicant to the entire structure, treating all locations in accordance with maximum rates permitted by applicable regulation and manufacturer's instructions.

C. Re-treat disturbed treated soil with same toxicant as original treatment.

D. If inspection or testing identifies the presence of termites, re-treat soil and re-test.

3.03 PROTECTION OF FINISHED WORK

A. Do not permit soil grading over treated work.

END OF SECTION

SECTION 32 11 16 – AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 SUMMARY

Section Includes:

A. Preparing subgrades for aggregate.

B. Aggregate base course for gravel parking areas and drives.

1.2 DEFINITIONS

A. Aggregate Base Course: aggregate layer above the subgrade and ground surface for gravel parking areas and below the asphalt on paved walking trails

B. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below aggregate base course.

1.3 SUBMITTALS

A. Product Data: For each type of the following manufactured products required:
   1. Aggregate base course
   2. Geotextile

B. Samples for Verification: For the following products, in sizes indicated below:
   1. Geotextile: 12 by 12 inches

1.4 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aggregate Base Course: Aggregate produced in accordance with Section 520 in the 2018 NCDOT Standard Specifications for Roads and Structures.

2.2 GEOTEXTILES

A. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following, measured per test methods referenced:

B. Survivability: Class 2; AASHTO M 288.

C. Survivability: As follows:
   1. Grab Tensile Strength: 200 lbf; ASTM D 4632.
   2. Tear Strength: 75 lbf; ASTM D 4533.
   3. Puncture Strength: 90 lbf ; ASTM D 4833.

D. Apparent Opening Size: No. 50 sieve, maximum; ASTM D 4751.

E. Permittivity: 0.05 per second, minimum; ASTM D 4491.

F. UV Stability: 70 percent after 500 hours' exposure; ASTM D 4355.

PART 3 - EXECUTION

3.1 SUBGRADE PREPARATION

A. Protect and maintain erosion and sedimentation controls during earth-moving operations.

B. Protect subgrades from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

C. The subgrade shall be thoroughly compacted and constructed to the line, grade, and cross section on the drawings or as directed by the Engineer.

D. Prior to placement of aggregate base material, proofroll the subgrade with a fully-loaded tandem-axle dumptruck in the presence of the qualified Representative of the Owner's Testing Agency or Inspector.

E. Fix, correct, or remediate areas that demonstrate instability at the direction of the Testing Agency's Representative or Inspector.

3.2 DEWATERING

A. Prevent surface water from ponding on prepared subgrades and from flooding Project site.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

3.3 STORAGE OF SOIL MATERIALS

A. Stockpile aggregate materials without intermixing with subgrade soils. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.4 AGGREGATE BASE COURSE

A. Place aggregate base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place aggregate base course as follows:
   1. If required based on site conditions, install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends, and extending at least 1 foot beyond all paved areas in each direction.
   2. Shape aggregate base course to required crown elevations and cross-slope grades within 1 inch of the specified thickness on the drawings and no more than ½ inch variance over 100 feet.
   3. Place and compact aggregate base course layers which are 10 inches or less in thickness in single layers.
   4. Place and compact aggregate base course layers which exceed 10 inches in thickness in layers of equal thickness.
   5. Compact aggregate base course within 2 percent of optimum moisture content to an average of 98 percent of the maximum dry unit weight as determined by ASTM D 1557 with no individual test below 95 percent of the maximum dry unit weight determined by the optimum density and moisture content provided by NCDOT.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to evaluate subgrades prior to placement of aggregate base course and test and evaluate each layer of aggregate base course. Proceed with placement of aggregate base only after inspection and repair of subgrade is approved by testing agency.

C. Testing agency will test compaction of aggregate base in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
   1. Drive lanes and roads: 5 density, moisture, and depth tests within a road section defined by road alignment between two intersecting streets
   2. Paved trails: Each compacted layer, at least one test for every 250 linear feet or less of paved trail.

D. When testing agency reports that aggregate base courses have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace materials to depth required; recompact and retest until specified compaction is obtained.

3.6 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

END OF SECTION

SECTION 32 12 16 - ASPHALT PAVING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Full-Depth Reclamation
   2. Hot-mix asphalt paving.
   3. Hot-mix asphalt paving overlay.
   4. Asphalt surface treatments.
   5. Pavement-marking paint.

1.2 DEFINITIONS

A. Full-depth reclamation (FDR) with cement: Shall consist of pulverizing and mixing existing asphalt and base course material with Portland cement, soil and water to produce a dense, hard, cement treated base. It shall be proportioned, mixed, placed, compacted, and cured in accordance with this specification, and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans.

B. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 and Standard Specifications of North Carolina Department of Transportation (NCDOT) for definitions of terms.

1.3 SUBMITTALS

A. FDR: Contractor shall submit a proposed plan of action to the Engineer for approval at least 14 days prior to commencement of FDR. The proposed plan shall include proposed procedure, equipment and cement content to be utilized.

B. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

C. Shop Drawings: Indicate pavement markings and lane separations.

D. Material Certificates: For each paving material, from manufacturer.

E. Material Test Reports: For each paving material.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by NCDOT.

B. Installer Qualifications: Imprinted-asphalt manufacturer's authorized installer who is trained and approved for installation of imprinted asphalt required for this Project.

C. Testing Agency Qualifications: Qualified according to ASTM D 3666 and NCDOT for testing indicated.

D. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the NCDOT Standard Specifications (latest version) and the Wake County for asphalt paving work.
   1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

E. Pre-installation Conference: Conduct conference at Project Site.
   1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
      a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
      b. Review condition of subgrade and preparatory work.

c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

F. Contractor shall provide and conduct a quality control program as defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to the production of the pavement in accordance with NCDOT's "Hot Mix Asphalt Quality Management System" (HMA / QMS) manual which is in force on the date of the contract advertisement.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if base is frozen, wet or excessively damp, if rain is imminent or expected before time required for adequate cure, in accordance with Table 610-3 from the NCDOT Standard Specifications.

B. Pavement-Marking: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 PRODUCTS

2.1 FDR MATERIALS

A. Recycled Asphalt Pavement (RAP) and Base Material: Shall consist of the existing asphalt pavement, existing base course material and/or subgrade material. The base course and subgrade material shall not contain roots, topsoil, or any material deleterious to its reaction with cement. The particle distribution of the processed material shall be such that 100% passes a 3-inch (75 mm) sieve, at least 95% passes a 2 –inch (50mm) sieve, and at least 55% passes a No. 4 (4.75 mm) sieve.

B. Mix Design: A mix design has been performed by S&ME, Inc. on samples obtained from representative areas. The required depth of reclamation and percentage of cement required is provided on the project plans.

C. Portland Cement: Shall comply with the latest specifications for Portland cement (ASTM C150, ASTM C1157, or AASHTO M85) or blended hydraulic cements (ASTM C595, ASTM C1157, or AASHTO M240).

D. Water: Shall be free from substances deleterious to the hardening of the cement-treated material.

2.2 AGGREGATES

A. Coarse Aggregate, Fine Aggregate, and Mineral Filler
1. In accordance with the requirements of Section 520 NCDOT Standard Specifications and the Drawings.

2.3 ASPHALT MATERIALS

A. All materials utilized in the production of hot mix asphalt shall meet NCDOT applicable requirements of the provisions from Section 610 titled "Asphalt Concrete Plant Mix Pavement," for the type of Superpave plant mix pavement specified on the Drawings.

2.4 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by NCDOT; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
   1. Initial Course: Types I-19.0C and S-9.5B.
   2. Surface Course: Types S-9.5B.

PART 3 – EXECUTION

3.1 FULL DEPTH RECLAMATION (FDR)

A. Contractor should organize a pre-FDR meeting to include representatives of Contractor, Engineer, Geotechnical Engineer, and Owner's Testing Agency. Minimizing dust during cement application should be amongst topics discussed.

B. Equipment
   1. Description: FDR may be constructed with any machine or combination of machines or equipment that will produce a satisfactory product meeting the requirements for pulverization, cement and water application, mixing, compacting, finishing, and curing as provided in this specification.
   2. Mix Methods: Mixing shall be accomplished in place, using single-shaft or multiple-shaft mixers. Agricultural disks or motor graders are not acceptable mixing equipment.
   3. Cement Proportioning: Spreading of the Portland cement shall be done with a spreader truck designed to spread dry particulate such as Portland cement to insure a uniform distribution. Spreaders or distributors used shall be able to demonstrate a consistent and accurate application rate, as well as dust control during application. The mechanical cement spreader shall be capable of dispensing a measured quantity of cement +/- 3 lbs per square yard in advance of the pulverizor just prior to each pass of stabilizing operation. The pulverizor shall abut or slightly overlap (0.5") previous pass to ensure a continuous homogeneous mass of granular material and cement. Cement spreader does not have to abut or overlap previous pass as long as the calculated quantity of cement is dispersed in front of the pulverizor.
   4. Application of Water: Water may be applied through the mixer or with water trucks equipped with pressure-spray bars. If using the spray bar system, road base shall be pre-wet to obtain optimum moisture content prior to dispensing of cement.
   5. Compaction: The processed material shall be compacted with one or a combination of the following: Tamping or grid roller, pneumatic-tire roller, steel-wheel roller, vibratory roller, or vibrating-plate compactor. The full-depth recycled material shall be rolled with a vibratory pad/tamping foot roller and a vibratory steel drum soil compactor. The pad/tamping foot roller drum shall have a minimum of 112 tamping feet 3 in in height, a minimum contact area per foot of 17 in^2, and a minimum width of 84 in. The vibratory steel drum roller shall have a minimum 84 in width single drum.

C. Construction Requirements
   1. General
      a. Preparation:
         1. Prior to the start of the reclamation, all utilities and drainage systems shall be relocated as necessary.
         2. Methods, equipment, tools, and any machinery to be used during construction shall be approved by the Engineer prior to the start of the project. Prior to actual reclaiming, drop inlets or catch basins that might be affected shall be sufficiently barricaded to prevent reclaimed subbase material, silt, or runoff from plugging the drainage system.
         3. Sufficient drainage must be provided for each stage of construction so that ponding does not occur on the reclaimed sub-base course prior to the placement of bituminous concrete.

4. Reclamation shall be accomplished by means of a self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing bituminous concrete pavement to depths of up to 12 inches with one pass. The machine shall be equipped with an adjustable grading blade leaving its path generally smooth for initial compaction. Equipment such as road planers or cold milling machines designed to mill or shred the existing bituminous concrete, rather than crush or fracture it, shall not be allowed.
5. Existing bituminous concrete pavement and any underlying granular material and soil within the design depth must be pulverized and mixed so as to form a homogenous mass of reclaimed sub-base material which will bond together when compacted.
6. In areas where the vertical or horizontal geometry of the proposed roadway is different than that of the existing, the pavement shall be reclaimed in-place and the reclaimed material sub-base placed in windrows or stockpiled while any filling or excavation is performed. When the proposed sub-grade elevation is achieved, the reclaimed sub-base material will be placed back onto the pavement in lifts no greater than five (5) inches in depth before being compacted.
7. Reshaping using the reclaimed sub-base material should be minimized in order to ensure that the roadway has a uniform thickness of reclaimed sub-base material throughout. Unless otherwise specified, when shaping of the pavement is required, it should be performed utilizing additional sub-base or processed aggregate base. The reclaimed sub-base material shall be compacted prior the placement of any additional granular material used (sub-base or processed aggregate base). Subsequent to the compaction of the reclaimed sub-base materials, any reshaped material or additional material placed on the pavement shall not exceed five (5) inches in depth before being compacted.
8. The reclaimed sub-base material shall be compacted to the requirements above prior to placement of traffic on the pavement.
9. A motor grader shall be used for shaping, fine grading, and finishing the surface of the reclaimed material or any other granular materials placed to form the surface prior to paving.
10. Any surface irregularities which develop during or after the above described work shall be corrected until it is brought to a firm and uniform surface satisfactory to the Engineer.

b. Mixing and Placing: FDR processing shall not commence when the stone aggregate or subgrade is frozen, or when the air temperature is below 40°F. Moisture in the base course material at the time of cement application shall not exceed the quantity that will permit a uniform and intimate mixture of the pulverized asphalt, base material, and cement during mix operations, and shall be within 2% of the optimum moisture content for the processed material at start of compaction. The operation of cement application, mixing, spreading, compacting, and finishing shall be continuous and completed within 2 hours from the start of mixing. Any processed material that has not been compacted and finished shall not be left undisturbed for longer than 30 minutes.
c. Scarifying: Before cement is applied, initial pulverization or scarification may be required to the full depth of mixing. Scarification or pre-pulverization is a requirement for the following conditions: 1) When the processed material is more than 3% above or below optimum moisture content. When the material is below optimum moisture content, water shall be added. The pre-pulverized material shall be sealed and properly drained at the end of the day or if rain is expected. 2) For slurry application of cement, initial scarification shall be done to provide a method to uniformly distribute the slurry over the processed material without excessive runoff or ponding.
d. Application of Cement: The specified quantity of cement shall be applied uniformly in a manner that minimizes dust and is satisfactory to the engineer. If cement is applied as

a slurry, the time from first contact of cement with water to application on the soil shall not exceed 60 minutes. The time from cement placement on the soil to start of mixing shall not exceed 30 minutes.

e. Mixing: Mixing shall begin as soon as possible after the cement has been spread and shall continue until uniform mixture is produced. The mixed material shall meet the following gradation conditions: 1) The final mixture (bituminous surface, granular base, and subgrade soil) shall be pulverized such that 100% passes the 3-inch (75 mm) sieve, at least 95% passes the 2-in. (50 mm) sieve, and at least 55% passes the No. 4 (4.75 mm) sieve. No more than 50% of the final mixed material shall be made of the existing bituminous material unless approved by the engineer and included in a mixture design. Additional material can be added to the top or from the subgrade to improve the mixture gradation, as long as this material was included in the mixture design. 2) The final pulverization test shall be made at the conclusion of mixing operations. Mixing shall be continued until the product is uniform in color, meets gradation requirements, and is at the required moisture content throughout. The entire operation of cement spreading, water application, and mixing shall result in a uniform pulverized asphalt, soil, cement, and water mixture for the full design depth and width.

f. Compaction: The processed material shall be uniformly compacted to a minimum of 98% of maximum density. Field density of compacted material can be determined by nuclear method in the direct transmission mode (ASTM D2922) or sand cone method (ASTM D1556). Optimum moisture and maximum density shall be determined prior to start of construction and also in the field during construction by a moisture-density test (ASTM D558). At the start of compaction, the moisture content shall be within 2% of the specified optimum moisture. No section shall be left undisturbed for longer than 30 minutes during compaction operations. All compaction operations shall be completed within 2 hours from start of mixing.

g. Finishing: As compaction nears completion, the surface of the FDR material shall be shaped to specified lines, grades, and cross section. If necessary or as required by the engineer, the surface shall be lightly scarified or broom-dragged to remove imprints left by equipment or to prevent compaction planes. Compaction shall then be continued until uniform and adequate density is obtained. During the finishing process the surface shall be kept moist by means of water spray devices that will not erode the surface. Compaction and finishing shall be done in such a manner as to produce a dense surface free of compaction planes, cracks, ridges, or loose material. All finishing operations shall be completed within 4 hours from start of mixing.

h. Curing:
    1. Finished portions of the FDR base that are traveled on by equipment used in constructing an adjoining section shall be protected in such a manner as to prevent equipment from marring or damaging completed work.
    2. After completion of final finishing, the surface shall be cured by application of a bituminous or other approved sealing membrane, or by being kept continuously moist for a period of 7 days with a water spray that will not erode the surface of the FDR base. If curing material is used, it shall be applied as soon as possible, but not later than 24 hours after completing finishing operations. The surface shall be kept continuously moist prior to application of curing material.
    3. For bituminous curing material, the FDR base surface shall be dense, free of all loose and extraneous materials, and shall contain sufficient moisture to prevent excessive penetration of the bituminous material. The bituminous material shall be uniformly applied to the surface of the completed cement treated material. The exact rate and temperature of application for complete coverage, without undue runoff, shall be specified by the engineer.

4. Should it be necessary for construction equipment or other traffic to use the bituminous-covered surface before the bituminous material has dried sufficiently to prevent pickup, sufficient sand cover shall be applied before such use.
5. Sufficient protection from freezing shall be given to the cement-treated material for 7 days after its construction or as approved by the engineer. Contractor assumes all materials and costs to keep FDR base moist for a period of (7) seven days, or until the base course is applied.

i. Traffic: Completed portions of FDR base can be opened immediately to low-speed local traffic and to construction equipment, provided the curing material or moist curing operations are not impaired, and provided the FDR base is sufficiently stable to withstand marring or permanent deformation. The section can be opened up to all traffic after the FDR base has received a curing compound or subsequent surface and is sufficiently stable to withstand marring or permanent deformation. If continuous moist curing is employed in lieu of a curing compound or subsequent surfacing within 7 days, the FDR base can be opened to all traffic after the 7-day moist curing period, provided the FDR base has hardened sufficiently to prevent marring or permanent deformation.

j. Surfacing: Subsequent pavement layers can be placed any time after finishing, as long as the soil-cement is sufficiently stable to support the required construction equipment without marring or permanent distortion of the surface.

k. Maintenance: The contractor shall maintain the cement-treated material in good condition until all work is completed and accepted. Such maintenance shall be done by the contractor at their own expense. Maintenance shall include immediate repairs of any defects that may occur. If it is necessary to replace any processed material, the replacement shall be for the full depth, with vertical cuts, using either cement-treated material or concrete. No skin patches will be permitted.

2. Measurement and Payment

a. Measurement: This work will be measured.
   1. In square yards of completed and accepted FDR base course as determined by the specified lines, grades, and cross sections shown on the plan.
   2. In tons of cement incorporated in to the FDR base course in accordance with the percent cement specified in the mix design or additional instructions of the engineer.

b. Payment: This work will be paid for at the contract unit price per square yard of FDR base course and at the contract unit price per ton of cement furnished, multiplied by the quantities obtained in accordance with above. Such payment shall constitute full reimbursement for all work necessary to complete the FDR base course, including water, curing, quality control, and all other incidental operations.

3.2 EXAMINATION

A. Verify that base course is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with a loaded, tandem-axel dump truck making repeated passes over the subject area to identify soft pockets and areas that rut, pump or deflect excessively. Proof- rolling shall be observed and areas repaired as recommended by Owner's Testing Agency prior to paving. Do not proof-roll wet or saturated base course.
   1. Completely proof-roll base course in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
   2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 20 tons.
   3. Excavate soft spots, unsatisfactory stone and/or soils, and areas of excessive pumping or rutting, as determined by Owner's Testing Agency, and replace with compacted ABC stone as directed.

C. Proceed with paving only after unsatisfactory conditions have been corrected and verified by Owner's Testing Agency.

3.3 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared base course is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared surface of compacted-aggregate base before applying paving materials.

C. Tack Coat: Apply uniformly to surfaces of existing pavement and abutting concrete surfaces at a rate of 0.05 to 0.15 gal./sq. yd.
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off in accordance with NCDOT requirements. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted per Drawings.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
   1. Clean contact surfaces and apply tack coat to joints.
   2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
   3. Offset transverse joints, in successive courses, a minimum of 24 inches.
   4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
   5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
   6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.6 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted as follows:
   1. Target Average Density (I-19.0C, B-25.0C): 92 percent of theoretical maximum density according to AASHTO T166, T275, or T331, with no individual test less than 90 percent nor greater than 100 percent.
   2. Target Average Density (S-9.5B): 90 percent of theoretical maximum density according to AASHTO T166, T275, or T331, with no individual test less than 88 percent nor greater than 98 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness. Cutting and patching of newly placed asphalt is unacceptable. If defective asphalt is discovered, milling of asphalt and replacement with new asphalt will be required.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Initial Course: Plus or minus 1/2 inch or per NCDOT requirements, whichever is more stringent.
   2. Surface Course: Plus 1/4 inch, no minus or per NCDOT requirements, whichever is more stringent.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
   1. Initial Course: 1/4 inch.
   2. Surface Course: 1/8 inch.
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.8 PAVEMENT MARKING

A. Apply temporary traffic marking paint – Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than three minutes.

B. Permanent Pavement Markings – Thermoplastic Composition shall be placed in accordance with NCDOT specifications.
   1. Thermoplastic Alkyd/Maleic and Hydrocarbon pavement markings shall be composed of the following materials:

COMPONENT	BY WEIGHT
Alkyd/Maleic Binder	18.0% Min.
Hydrocarbon Binder	22.0% Min.
Glass Beads (Premixed)	30.0% Min.
Titanium Dioxide (ASTM D-476, Type 2)	10.0% Min.
Yellow Pigment (For Yellow Marking Only)	4.0% Min.

   2. Calcium carbonate and inert fillers shall be opted by the manufacturer, providing all other specifications are met.
   3. The total silica content used in the formulation of the thermoplastic shall be the premixed glass beads.
   4. The pigment, beads, and filler shall be uniformly dispersed in the binder.
   5. The Alkyd/Maleic binder shall consist of a mixture of synthetic resins (at least on synthetic resin shall be solid at room temperature) and high boiling point plasticizers. At least one-third of the binder composition shall be 100% maleic-modified glycerol ester of resin and shall be no less than 10% by weight of the entire material formulation. The binder shall contain no petroleum Hydrocarbon resins, tall oil resins or rosins, or any combination of tall oil resins with maleic- modified glycerol esters of rosin.

6. The Hydrocarbon binder shall consist of a mixture of Hydrocarbon resins (at least one Hydrocarbon resin shall be solid at room temperature) and high boiling point plasticizers.
7. The thermoplastic material shall be free of contaminates and shall be dry blended or hot mixed from 100% virgin stock using no reprocessed materials.
8. The thermoplastic material shall be formulated such that when it is on the roadway surface at any natural temperature it exists in a hard, solid state with cold ductility that permits normal movement with the road surface without chipping or cracking.
9. The thermoplastic material shall not deteriorate or discolor when held at the application temperature for periods of time up to 4 hours or upon repeated reheating (a minimum of 4 times).
10. The color, viscosity, and chemical properties versus temperature characteristics of the thermoplastic material shall remain constant for up to 4 hours at the application temperature and shall be the same from batch to batch.
11. The thermoplastic material shall be readily applicable at temperatures between 400 & 440 degrees F from the approved equipment to produce lines and symbols of the required above the pavement thickness.
12. All stencils utilized for construction of pavement markings shall be provided to the Owner following Final Completion.

3.9 FIELD QUALITY CONTROL

A. Contractor is responsible for quality control in accordance with NCDOT's "Hot Mix Asphalt Quality Management System" (HMA/QMS) manual including, but not limited to thickness, smoothness, and in-place density.

B. Contractor is responsible for providing Owner's Testing Agency with theoretical daily moving average from plant for each day's placement and each mix type placed during that day.

C. Testing Agency: Owner's Testing Agency will core a minimum of three locations for each day's placement per mix type. The cores will be evaluated by the Owner's Testing Agency for thickness and compaction.

D. Contractor to replace and compact hot-mix asphalt where core tests were taken.

E. Remove and replace hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

F. FDR Observations and Testing
   1. Description: The Owner will provide a testing agency to perform observations and tests as deemed necessary. These observations and tests may include, but shall not be limited to:
      a. Recycling operations including recycling speed, yield monitoring, monitoring treatment depth, procedures for avoiding recycling and curing in inclement weather, methods to ensure that segregation is minimized, procedures for mix design modification, grading and compacting operations, and cement application procedure.
      b. Density testing of the recycled material will be performed using the nuclear or sand cone methods.
      c. Only those materials, machines, and methods meeting the requirements of the contract documents shall be used unless otherwise approved by the engineer.
      d. All testing of processed material or its individual components, unless otherwise provided specifically in the contract documents, shall be in accordance with the latest applicable ASTM or AASHTO specifications in effect as of the date of advertisement for bids on the project.

3.10 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow milled materials to accumulate on-site.

END OF SECTION

SECTION 32 13 13 - CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Walks.

1.02 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Light Duty Concrete
   2. Heavy Duty Concrete

B. Mock-up: For each type of product or exposed finish, prepared as Samples of size indicated below:
   1. 48”x48” square mock-up required for review and approval by Owner and Landscape Architect.

C. Other Action Submittals:
   1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

D. The contractor shall stake the layout and alignment of all pavements, walls and other site features in the field for approval by the Landscape Architect prior to start of construction.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer.

B. Material Certificates: For the following, from manufacturer:
   1. Cementitious materials.
   2. Admixtures.
   3. Curing compounds.
   4. Applied finish materials.

C. Material Test Reports: For each of the following:
   1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

D. Field quality-control reports.

E. Product Submittals: Submit cut sheets of detectable warning paver selection. Include paver choice and color.

1.05 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

C. Slip Resistance: The project shall conform to the ADA recommendations for ground surfaces.

D. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

E. ACI Publications: Comply with ACI 301 unless otherwise indicated.

F. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.
      c. Sub base and base preparation
      d. Form work layout
      e. Finish, finish tools and finishing process
   2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Concrete paving subcontractor.

1.06 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Schedule concrete work only during job and weather that can produce consistent results.

PART 2 PRODUCTS

2.01 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces. Use material appropriate to obtain the correct quality and alignments.
   1. Use 2” thick wood forms or formed steel forms for straight lines and rectangular applications
   2. Use flexible forms capable of delivering smoothly curved formwork free of kinks, bulges, or flats. Forms can be steel, plastic or wood, but must have adequate joining methods to allow the smooth flow of curved lines through the union of form sections.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.02 STEEL REINFORCEMENT

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from steel wire into flat sheets.

C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 ; deformed.

D. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars galvanized after fabrication according to ASTM A 767/A 767M, Class I coating. Cut bars true to length with ends square and free of burrs.

2.03 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:
   1. Portland Cement: ASTM C 150, gray Portland cement Type I. The following are allowed supplements:
      a. Fly Ash: ASTM C 618, Class F.
      b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S, uniformly graded. Provide aggregates from a single source.
   1. Maximum Coarse-Aggregate Size: 1 inches nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: Potable and complying with ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.04 CURING MATERIALS

A. Water: Potable.

B. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Anti-Hydro International, Inc.; A-H Curing Compound #2 DR WB.
      b. ChemMasters; Safe-Cure Clear.
      c. Conspec by Dayton Superior;
      d. Dayton Superior Corporation; Day-Chem Rez Cure (J-11-W).
      e. Edoco by Dayton Superior;
      f. Euclid Chemical Company (The), an RPM company; Kurez W VOX.
      g. Kaufman Products, Inc.; Thinfilm 420.
      h. Lambert Corporation; AQUA KURE - CLEAR.
      i. L&M Construction Chemicals, Inc.; L&M CURE R.
      j. Meadows, W. R., Inc.; 1100-CLEAR SERIES.
      k. Nox-Crete Products Group; Resin Cure E.
      l. SpecChem, LLC; PaveCure Rez.
      m. Symons by Dayton Superior; Resi-Chem Clear.
      n. Tamms Industries, Inc., Euclid Chemical Company (The); TAMMSCURE WB 30C.
      o. TK Products, Division of Sierra Corporation;.
      p. Vexcon Chemicals Inc.; Certi-Vex Enviocure 100.

2.05 LIGHT DUTY CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 , for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
   1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
   2. When automatic curb and gutter machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.

B. Proportion mixtures to provide normal-weight concrete with the following properties:
   1. Light Duty Compressive Strength (28 Days): 3500 psi.
   2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.50.
   3. Slump Limit: 5 inches, plus or minus 1 inch .

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
   1. Air Content: 5-1/2 percent plus or minus 1.5 percent.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing admixture or plasticizing and retarding admixture in concrete as required for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:
   1. Fly Ash or Pozzolan: 25 percent.
   2. Ground Granulated Blast-Furnace Slag: 50 percent.
   3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

2.06 HEAVY DUTY CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
   1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
   2. When automatic curb and gutter machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.

B. Proportion mixtures to provide normal-weight concrete with the following properties:
   1. Heavy Duty Compressive Strength (28 Days): 4000 psi.
   2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.50.
   3. Slump Limit: 5 inches, plus or minus 1 inch.

C. Add air-entraining admixture at manufacturer’s prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
   1. Air Content: 5-1/2 percent plus or minus 1.5 percent.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer’s written instructions.
   1. Use water-reducing admixture or plasticizing and retarding admixture in concrete as required for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Ground Granulated Blast-Furnace Slag: 50 percent.
3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

2.07 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
   1. When air temperature is between 85 and 90 deg F , reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F , reduce mixing and delivery time to 60 minutes.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances. Grades should be compacted, smooth and free of dips, ridges or other potential snags that could cause less predictable cracking.

B. Proof-roll prepared base surface below concrete paving to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll base in one direction for pedestrian applications and repeat in perpendicular direction for vehicular applications. Limit vehicle speed to 3 mph .
   2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 20 tons .
   3. Correct base with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Division 31 Section "Earth Moving." Do not fill with concrete.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Remove loose material from compacted base surface immediately before placing concrete.

B. Place and compact base materials according to “Asphalt Paving” specifications for ABC gravel.

3.03 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.04 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.05 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
   1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
   1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.

C. Expansion Joints: Form isolation joints of preformed joint-filler strips abutting buildings, columns, footings, concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
   1. Locate expansion joints at intervals shown in the drawings but not more than 40'.
   2. Extend joint fillers full width and depth of joint.
   3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
   4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
   5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
   6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
   7. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent concrete paving]:
   1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.06 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into.

G. Consolidate concrete according to ACI 301 by hand spading, rodding, or tamping.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
   1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

L. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
   1. When air temperature has fallen to or is expected to fall below 40 deg F , uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
   2. Do not use frozen materials or materials containing ice or snow.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

M. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
   1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
   3. Fog-spray forms and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.07 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface by hand floating. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
   1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3.08 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by curing compound as follows:
   1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.09 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch .
2. Thickness: Plus 3/8 inch , minus 1/4 inch .
3. Surface: Gap below 10-foot- long, unleveled straightedge not to exceed 3/8 inch .
4. Lateral Alignment and Spacing of Dowels: 1 inch .
5. Vertical Alignment of Dowels: 1/4 inch .
6. Contraction Joint Depth: Plus 1/4 inch , no minus.
7. Joint Width: Plus 1/8 inch , no minus.
8. Joint Spacing: as shown on the drawing
9. Joint alignment: when aligned with plan identified site element, ¼".
10. Edge alignment – no more than ½" out of alignment over 20'
11. Joint straightness – no more than ½" out of alignment over 20'

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for the first 20 yards and one each 100 cu. yd. thereafter or fraction thereof of each concrete mixture placed each day.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
   5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of five standard cylinder specimens for each composite sample.
   6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and three specimens at 28 days.
      a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
      b. If two of the three 28 days specimens fall below the specified strength, then the third specimen be shall be saved for testing at 56 days so that two specimens can be tested at 56 days.

C. Strength of each concrete mixture will be satisfactory if average of any two consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

H. Prepare test and inspection reports.

3.11 CONCRETE REJECTION AND REPLACEMENT

A. Concrete paving will be considered defective if it:
   1. Does not pass tests and inspections.
   2. Does not meet layout and alignments,
   3. Does not have a consistent color and texture
   4. Shows spalling, alligator cracking or cracking due to base failures.
   5. Jointing is installed after contraction cracking has occurred,
   6. Jointing and edges are not smooth curves or in straight lines as indicated by the drawings,
   7. Exceeds the gradients indicated on the plans,
   8. Does not adequately drain water away as shown on the drawings.

B. Defective concrete shall be removed immediately and replaced with acceptable concrete work at the Contractor’s expense.

3.12 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Engineer, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Final Inspection.

END OF SECTION

SECTION 32 13 73 – CONCRETE PAVING JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Cold-applied joint sealants.
   2. Cold-applied, fuel-resistant joint sealants.
   3. Joint-sealant backer materials.
   4. Primers.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Paving-Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.
   3. Joint-sealant formulation.
   4. Joint-sealant color.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Product Certificates: For each type of joint sealant and accessory.

C. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Testing: Test joint sealants using a qualified testing agency.

1.05 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 PRODUCTS

2.01 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and

application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.02 COLD-APPLIED JOINT SEALANTS

A. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.

B. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.

C. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T.

2.03 JOINT-SEALANT BACKER MATERIALS

A. No rigid plastic joint material for expansion joint and no rigid plastic cap over other expansion joint material.

B. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.04 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 EXECUTION

A. EXAMINATION

B. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.03 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:
   1. Place joint sealants so they fully contact joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.04 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Project Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

3.05 PAVING-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within concrete paving in areas other than service court area.
   1. Joint Location:
      a. Expansion and isolation joints in concrete paving.
   2. Joint Sealant: Single-component, nonsag, Single-component, self-leveling, silicone joint sealant, Multicomponent, nonsag, urethane, elastomeric joint sealant, Single component, pourable, urethane, elastomeric joint sealant, or Multicomponent, pourable, urethane, elastomeric joint sealant.
   3. Joint-Sealant Color: To match adjacent paving within manufacturer's standard range of colors.

B. Joint-Sealant Application: Fuel-resistant joints within concrete paving in service court area.
   1. Joint Location:
      a. Expansion and isolation joints in concrete paving.
   2. Joint-Sealant Color: To match adjacent paving within manufacturer's standard range of colors.

END OF SECTION

SECTION 32 14 00 - UNIT PAVING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Concrete pavers.
   2. Curbs and edge restraints.
   3. Steel edge restraints.

B. Alternates: Work in this Section is affected by an Alternate. Refer to Section 01 23 00-Alternates.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

A. Product Data:
   1. For materials other than water and aggregates.
   2. For the following:
      a. Pavers.
      b. Bituminous setting materials.
      c. Edge restraints.
      d. Steel edge restraints.

B. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C136.

C. Samples for Initial Selection: For each type of unit paver indicated and the following:
   1. Joint materials involving color selection.
   2. Exposed edge restraints involving color selection.

D. Samples for Verification: For full-size units of each type of unit paver indicated. Assemble no fewer than five Samples of each type of unit on suitable backing and grout joints. Include Samples of the following:
   1. Joint materials.
   2. Exposed edge restraints.

E. The contractor shall stake the layout and alignment of all pavements, walls and other site features in the field for approval by the Landscape Architect prior to start of construction.

F. Shop Drawings: Contractor to provide shop drawings for paver pedestal system. Refer to manufacturer for layout requirements.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.

C. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
   1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C67.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: A qualified unit paving installer. Installer's field supervisor personnel assigned to the Work shall have Concrete Paver Installer Certification from the Interlocking Concrete Pavement Institute (ICPI) with the following designations:
   1. Commercial Paver Technician Designation.

B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
   1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Final Acceptance.
   2. 10’ x 10’ square mock-up required for review and approval by Owner and Architect.

1.06 PRECONSTRUCTION TESTING

A. Preconstruction Adhesion and Compatibility Testing: Submit to latex-additive manufacturer, for testing as indicated below, Samples of flooring materials that will contact or affect mortar and grout that contain latex additives.
   1. Use manufacturer's standard test methods to determine whether mortar and grout materials will obtain optimal adhesion with, and will be nonstaining to, installed brick and other materials constituting brick flooring installation.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

E. Store asphalt cement and other bituminous materials in tightly closed containers.

1.08 FIELD CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Bituminous Setting Bed:
   1. Install bituminous setting bed only when ambient temperature is above 40 deg F and when base is dry.
   2. Apply asphalt adhesive only when ambient temperature is above 50 deg F (10 deg C) and when temperature has not been below 35 deg F (2 deg C) for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.

1.09 MAINTENANCE MATERIALS

A. Provide (25) twenty-five additional pavers of each paver type to Owner for future use.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.
   1. Wausau Tile – EcoPremier Architectural Paver.
   2. Hanover Traditional Prest Brick Paver
   3. Belgard – Moduline

2.02 CONCRETE PAVERS

A. Concrete Pavers On-Grade, Solid Interlocking Paving Units: Complying with ASTM C936/C936M and resistant to freezing and thawing when tested according to ASTM C67, made from normal-weight aggregates.
   1. Thickness: 3 inches on sand
   2. Face Size and Shape:
      a. Type A 6-by-12-inch rectangle, Color: Light grey
      b. Type B 6-by-12-inch rectangle, Color: Charcoal
   3. Color: As selected by Landscape Architect from manufacturer's full range.

B. Concrete Pavers in Fire Lane, Solid Interlocking Paving Units: Complying with ASTM C936/C936M and resistant to freezing and thawing when tested according to ASTM C67, made from normal-weight aggregates.
   1. Thickness: 3 inches on sand and concrete – see plans.
   2. Face Size and Shape:
      a. 4-by-8-inch rectangle, Color: See below.
   3. Color: As selected from manufacturer’s full range to match Architect’s sample.

2.03 ACCESSORIES

A. Cork Joint Filler: Preformed strips complying with ASTM D1752, Type II.

B. Compressible Foam Filler: Preformed strips complying with ASTM D1056, Grade 2A1.

2.04 AGGREGATE SETTING-BED MATERIALS

A. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.

B. Stone Screenings for Leveling Course: Sound stone screenings complying with ASTM D448 for Size No. 10.

C. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
   1. Provide sand of color needed to produce required joint color.
   2. Polymeric sand in joints.

D. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

2.05 BITUMINOUS SETTING-BED MATERIALS

A. Primer for Base: ASTM D2028/D2028M, cutback asphalt, grade as recommended by unit paver manufacturer.

B. Fine Aggregate for Setting Bed: ASTM D1073, No. 2 or No. 3.

C. Asphalt Cement: ASTM D3381/D3381M, Viscosity Grade AC-10 or Grade AC-20.

D. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.

E. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
   1. Provide sand of color needed to produce required joint color.
   2. Polymeric sand for all joints.

2.06 BITUMINOUS SETTING-BED MIX

A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to 300 deg F (149 deg C).

2.07 VEGETATED ROOF PEDESTALS

A. Paver Supports: Paver manufacturer's standard SBR rubber, high-density polyethylene, or polyurethane paver support assembly, including adjustable pedestals, shims, and spacer tabs for joint spacing of 1/8 inch.

2.08 CURBS AND EDGE RESTRAINTS

A. Steel Edge Restraints: Manufacturer's standard painted steel edging 1/4 inch (6.4 mm) thick by 5 inches (125 mm) high with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c. and steel stakes 15 inches (380 mm) long for each loop. Securely fasten steel edge to concrete slab with expansion bolts.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Border Concepts, Inc.
      b. Collier Metal Specialties, Inc.
      c. J. D. Russell Company (The).
      d. Sure-loc Edging Corporation.
   2. Color: Black

B. Job-Built Concrete Edge Restraints: Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 3000 psi (20 MPa).

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

C. Proof-roll prepared subgrade according to requirements in Section 312000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

3.03 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
   1. For concrete pavers, a block splitter may be used.

D. Joint Pattern:
   1. Concrete Unit Pavers in Fire Lane: Herringbone.

2. Concrete Unit Pavers at Grade: See plans.

E. Tolerances:
1. Do not exceed 1/32-inch unit-to-unit offset from flush (lippage) or 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.
2. Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

F. Expansion and Control Joints:
1. Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 32 14 00 ‘’Concrete Paving Joint Sealants’’ and plans.
2. Provide cork joint filler at locations and of widths indicated. Install joint filler before setting pavers. Make top of joint filler flush with top of pavers.

G. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
2. For metal edge restraints with top edge exposed, drive stakes at least 1 inch (25 mm) below top edge.
3. Install job-built concrete edge restraints to comply with requirements in Section 32 13 13 “Concrete Paving”.

H. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.

3.04 VEGETATED PAVER INSTALLATION

A. Installation: Install walkway pavers according to manufacturer's written instructions.

B. Install paver supports according to pedestal manufacturer's written instructions. Adjust for final level and slope with shims.

C. Loosely set walkway pavers, maintaining a uniform joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.
1. Lay out pavers per plans.

D. Tolerances: Do not exceed 1/16-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.

3.05 BITUMINOUS SETTING-BED APPLICATIONS

A. Apply primer to concrete slab or binder course immediately before placing setting bed.

B. Prepare for setting-bed placement by locating 3/4-inch-deep control bars approximately 11 feet (3.3 m) apart and parallel to one another, to serve as guides for striking board. Adjust bars to subgrades required for accurate setting of paving units to finished grades indicated.

C. Place bituminous setting bed where indicated, in panels, by spreading bituminous material between control bars. Spread mix at a minimum temperature of 250 deg F (121 deg C). Strike setting bed smooth, firm, even, and not less than 3/4 inch (19 mm) thick. Add fresh bituminous material to low, porous spots after each pass of striking board. After each panel is completed, advance first control bar to next position in readiness for striking adjacent panels. Carefully fill depressions that remain after removing depth-control bars.
1. Roll setting bed with power roller to a nominal depth of 3/4 inch (19 mm). Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to 185 deg F (85 deg C).

D. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of 1/16 inch (1.6 mm). Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.

E. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.

F. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled. Polymeric sand required in joints.

3.06 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.

C. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.

END OF SECTION

SECTION 32 33 00 - SITE FURNISHINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Seating- Moveable tables and Chairs.
   2. Bicycle racks.
   3. Trash receptacles.
   4. Recycle receptacles.
   5. Bollards.

B. Alternates: Work in the section is affected by an Alternate/ refer to Section 01 23 00 - Alternates

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

C. Samples for Initial Selection: For units with factory-applied finishes.

D. Samples for Verification: For each type of exposed finish, not less than 6-inch- (152-mm-) long linear components and 4-inch- (102-mm-) square sheet components.
   1. Include full-size Samples of bench, bicycle rack, trash receptacle recycle receptacle. Approved samples may be incorporated into the Work.

1.03 INFORMATIONAL SUBMITTALS

A. Material Certificates: For site furnishings manufactured with preservative-treated wood.
   1. Indicate type of preservative used and net amount of preservative retained. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Trash Receptacle and Recycle Receptacle Inner Containers: Five full-size units for each size indicated, but no fewer than two units.
   2. Anchors: (12) for bench per manufacturers detail.

PART 2 PRODUCTS

2.01 SEATING – Moveable Tables and Chairs – Owner Provided Contractor Installed

A. Manufacturer:
   1. Victor Stanley
   2. Forms + Surfaces
   3. Landscape Forms – Basis of Design Chipman Chair

B. Frame: Steel

C. Seat and Table :
   1. Material: Solid Steel Frame composed of 98% recycled content
   2. Seat Surface Shape: Curved.
   3. Chair Style: Armless
   4. Overall Chair Width 20”
   5. Overall Chair Depth: 22”

6. Overall Chair Height: 33”.
7. Seating Configuration: single unit
8. Table style: Round
9. Overall Table Width: 36” Dia
10. Overall Table Height: 29.25”

D. Powder-coat finish.
1. Color: Architect to select from manufacturer’s full range.

2.02 BICYCLE RACKS

A. Manufacturers:
1. Dero Bike Rack Co. – Spire Rack
2. Forms + Surfaces – Trio Bike Rack
3. Landscape Forms – Bola Bike Rack

B. Bicycle Rack Construction:
1. Frame: 1-1/2” O.D. Stainless Steel; Schedule 40 Tube Style: Double-side parking.
a. Overall Height: 36”.
b. Overall Width: 20.48”
c. Capacity: Designed to accommodate no fewer than two bicycles.
2. Security: Designed to lock wheel and frame.
3. Installation Method: In ground mount. Embed 12” depth.
4. Standard Texture and Powder-coat.

C. Stainless Steel Finish: Brushed Finish, ASTM A480/A480M, No. 4.

2.03 TRASH RECEPTACLES & RECYCLE CONTAINERS

A. Manufacturers:
1. Victor Stanley – Model SD-45, Powder Coated, with rain bonnet
2. Landscape Forms – Chase Park, Powder Coated with side open.
3. Maglin Site Furniture – 200 Trash Container, Powder Coated with side opening

B. Steel Facing Surrounds: Evenly patterned, parallel flat steel straps, bars, or tubular shapes

C. Support Frames: Steel; welded. Powder coated. Color: Black.

D. Trash Receptacles:
1. Receptacle Shape and Form: Round cylinder; with opening for depositing trash in side of lid or top.
2. Lids and Tops: rain bonnet or side opening.
a. Description: rain bonnet, with sloped top.
3. Receptacle Height: 38.75”.
4. Overall Width: 28”.
5. Inner Container: Rigid plastic container with; designed to be removable and reusable.
6. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
7. Capacity: Not less than 45 gal. (170 L).
8. Service Access: side access; inner container and disposable liner lift or slide-out for emptying; keyed lock with two keys per receptacle.
9. Post Mount: Color-coated steel pipe; color to match receptacle; for mounting one receptacle(s).

E. Steel Finish: Galvanized and color coated.
1. Color: Black.

F. Attic Stock Requirements Trash Receptacle Inner Containers: Contractor to provide (3) full size inner receptacle units for each size indicated.

2.04 BOLLARDS

A. Service Yard Bollard Construction:
   1. Pipe OD: As indicated.
      a. Steel: Schedule 80 pipe.
   2. Style: As indicated.
   3. Overall Height: As indicated.
   4. Overall Width: As indicated.
   5. Overall Depth: As indicated.
   6. Installation Method: As indicated.

B. Steel:
   1. Color: Yellow OSHA Compliant.

2.05 MATERIALS

A. Steel and Iron: Free of surface blemishes and complying with the following:
   1. Plates, Shapes, and Bars: ASTM A36/A36M.
   2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
   3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
   4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
   5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
   6. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
   7. Malleable-Iron Castings: ASTM A47/A47M, grade as recommended by fabricator for type of use intended.
   8. Gray-Iron Castings: ASTM A48/A48M, Class 200.

B. Anchors, Fasteners, Fittings, and Hardware: Stainless steel, Galvanized steel, Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality, tamperproof, vandal and theft resistant, concealed, recessed, and capped or plugged.
   1. Angle Anchors: For inconspicuously bolting legs of site furnishings to on and/or below-grade substrate; extent as indicated.
   2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; wo per unit extent as indicated on by manufacturer.

C. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.

D. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

E. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
   1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.

2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

2.06 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

E. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.07 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.08 STEEL AND GALVANIZED-STEEL FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.09 STAINLESS STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
1. Run directional finishes with long dimension of each piece.
2. Directional Satin Finish: ASTM A480/A480M, No 4.
3. Dull Satin Finish: ASTM A480/A480M, No. 6.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION

G.

3.03 BOLLARDS

A. Service Yard Bollard Construction:
   1. Pipe OD: As indicated.

      a. Steel: Schedule 80 pipe.
   2. Style: As indicated.
   3. Overall Height: As indicated.
   4. Overall Width: As indicated.
   5. Overall Depth: As indicated.
   6. Installation Method: As indicated.

B. Steel:
   1. Color: Yellow OSHA Compliant.

3.04 MATERIALS

A. Steel and Iron: Free of surface blemishes and complying with the following:
   1. Plates, Shapes, and Bars: ASTM A36/A36M.
   2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
   3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
   4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
   5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
   6. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
   7. Malleable-Iron Castings: ASTM A47/A47M, grade as recommended by fabricator for type of use intended.
   8. Gray-Iron Castings: ASTM A48/A48M, Class 200.

B. Anchors, Fasteners, Fittings, and Hardware: Stainless steel, Galvanized steel, Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality, tamperproof, vandal and theft resistant, concealed, recessed, and capped or plugged.
   1. Angle Anchors: For inconspicuously bolting legs of site furnishings to on and/or below-grade substrate; extent as indicated.
   2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; wo per unit extent as indicated on by manufacturer.

C. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.

D. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

E. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
   1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.
   2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

3.05 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

E. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

3.06 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

3.07 STEEL AND GALVANIZED-STEEL FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

3.08 STAINLESS STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
   1. Run directional finishes with long dimension of each piece.
   2. Directional Satin Finish: ASTM A480/A480M, No 4.
   3. Dull Satin Finish: ASTM A480/A480M, No. 6.

PART 4 EXECUTION

4.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

4.02 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION

SECTION 32 84 00 – VEGETATED ROOF PLANTING IRRIGATION

PART 1 GENERAL

1.01 SUMMARY

A. The Drawings and Specifications herein apply to the Point of Connection and downstream.
   1. See Plans for Point of Connection.

B. Section Includes:
   1. Drip Irrigation for the Vegetated Roof planting only.
      a. Piping.
      b. Encasement for piping.
      c. Manual valves.
      d. Pressure-reducing valves.
      e. Automatic control valves.
      f. Automatic drain valves.
      g. Transition fittings.
      h. Dielectric fittings.
      i. Miscellaneous piping specialties.
      j. Sprinklers.
      k. Quick couplers.
      l. Drip irrigation specialties.
      m. Controllers.
      n. Boxes for automatic control valves.

1.02 DEFINITIONS

A. Irrigation Supply: Upstream of the Point of Connection, the irrigation supply includes the back flow preventer, the meter, feeds and taps.

B. Point of Connection: As shown on plans.

C. Irrigation System: Defined as components of the system that are located immediately d outside of the point of connection. See Engineering drawings and specifications for portions of the system within building.

D. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

E. System Main Feed – The piping and fittings required to move water from the Point of Connection to 5’ beyond the Main Isolation Valve

F. Main Isolation Valve – A master valve capable of shutting off the entire system before the system main splits - as located on the plan.

G. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.03 PERFORMANCE REQUIREMENTS

A. This Section describes work downstream of the Point of Connection (see plans for location).

B. Pressure – The Contractor is responsible for delivering a system capable of delivering working pressures to the equipment that are according to the manufacturer’s recommendations.

C. Irrigation zone control shall be automatic operation with controller and automatic control valves.

D. High rate delivery systems such as flood bubblers are not allowed.

E. Provide only high efficiency equipment capable of providing water accurately and efficiently. The system shall use drip irrigation for plants.

F. Provide an irrigation system that completely separates shrub irrigation. Maintain 100 percent head to head irrigation coverage of areas indicated.

G. No main piping or control wiring shall be located outside property lines or within road right of ways. Other system components may be allowed by the local municipality.

H. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and lights.

I. No valves, fittings, or joints are to be placed under paved surfaces, curbs or sidewalks. Where possible, crossing shall be uninterrupted stretches of pipe within sleeves sized according to the drawings.

J. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
   1. Irrigation System Feed: 400 psig.
   2. Irrigation Main Piping and Circuit Piping: 200 psig .
   3. Irrigation System 10 GPM minimum.
   4. Irrigation System to accommodate 40’ grade change
   5. Irrigation System 10 – 30 psi discharge pressure minimum.

K. The following are soil conditions found at the site:
   a. Structure: The soil structure of the site is compacted due to working and construction activity. This compaction will reduce standard infiltration rates.
   b. Infiltration Rate:
      1) Sandy loam: .5-.8 in/hr.
      2) Clay loam: .4--.5 in/hr
      3) Clay: .2-.3 in/hr.

L. Drip Emitters Per Plant – use the following guide to set the number of emitters per plant, based upon a 2 hour watering window [WW] and delivering matched water delivery per zone.

TABLE 1 – DRIP SYSTEM PERFORMANCE REQUIREMENTS

Type of plant	Plant Size at installation	Gal. Per week [X]	Gal/ WW	Minimum # emitters per plant	# emitters per plant at .5 gph	# emitters per plant at 1.0 gph	# emitters per plant at 1.5 gph	# emitters per plant at 2.0 gph	# emitters per plant at 3.0 gph
	2.5” to 4” caliper	60	4.3	4	9	4	3	2	1
Shrub									
	8” – 30” shrub or groundcover	7	0.5	1	1	1	N/A	N/A	N/A
Grasses and Peren-nials	Quart size plant	5	0.4	1	1	N/A	N/A	N/A	N/A
Plugs	4” pot and less	3		Grid of drip. See below					
• Minimum emitters per plant equals what is required to fully wet the root ball perimeter, not just one side • Emitters should be placed 4-6” inside the root ball									

- N/A – less than one emitter which is not possible
- Grid of drip should be the same rate as the plant spacing
- The Contractor shall use this table as a guide. Provide refinement of the system for different plant types and soil conditions.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Equipment Numbering System
   1. Use a coordinated numbering system for shop drawings, as-builts and field labeling as follows:
      a. Drip Valves – Use 51-99
      b. Valves, Pressure Regulators & Other Equipment - Use 100 and above

C. Delegated-Design Submittal Shop Drawings: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional designer licensed in the state of North Carolina responsible for their preparation. Submittal should include irrigation systems, drawn to scale in a CAD software, showing the following:
   1. Main piping
   2. Circuit piping
   3. Stream and spray rotors – with graphic radius indicated
   4. Automatic control valves
   5. Point of Connection location
   6. Time clock and rain sensor location
   7. Blow-off valves, isolation valves, quick coupler connections,
   8. Numbered valves with GPM calculated for each
   9. Coordination with site elements and utilities.
   10. Required Pressure at Point of Connection – The irrigation designer shall state the pressure required of irrigation system in PSI.
   11. System Pressure Loss – The designer shall state the calculated pressure loss from the Point of Connection to the furthest automated valve in PSI on the drawing.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. System Manual: A hard cover, 3 ring bound, exterior project titled, with table of contents for sprinklers, drip assemblies, controllers, pumps, quick couplers, rain sensors, and automatic control valves to include the following:
   1. Product cut sheets designating exact model number(s)
   2. Written schedule of operation including a winterization date, start up date, and controller timing schedule suggestions for spring, summer, and fall.
   3. Operation and Maintenance information of the provided equipment including a schedule of routine maintenance for cleaning and adjusting equipment.
   4. Reduced as-built plans bound with in the manual or in plastic sleeves.

B. Prepare an as-built CAD drawing of the installed system. The drawings shall be legible with no overlapping or hidden graphics. Provide enlargements of crowded or obscured areas. Take field measurements and indicate on the drawings the dimensions of key elements from known site points such as the buildings and roadways to showing installed conditions of the following equipment:
   1. Heads
   2. Main lines and lateral lines

3. Automatic valves, manual valves, blow-offs and quick couplers
4. Tap, meter, backflow, time clock and rain sensor
5. Circuit and sensor wires
6. Valve numbers corresponding to the time clock labeling, zone designation, and GPM for each zone.

1.07 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Drip-Tube System Tubing: Equal to 2% percent of total length installed for each type and size indicated, but not less than 100 feet.
   2. Drip emitters – provide 10 of each type.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: Must be a licensed irrigation contractor in the State of North Carolina according to NC Irrigation Licensing Board.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Architect and Owner no fewer than two days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Owner's written permission.
   3. Do not proceed with irrigation work until rough grade approval is given by the Landscape Architect.

PART 2 PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes. Supply components having pressure rating equal to or greater than system operating pressure.

B. Under pedestal pavers irrigation System Main Feed shall be the following:
   1. Schedule 80, PVC socket fittings; and solvent-cemented joints.

C. Under pedestal pavers irrigation Main Piping shall be the following:
   1. SDR 200, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

D. Circuit piping shall be the following:
   1. SDR 200, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

E. Risers: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

2.02 PIPING JOINING MATERIALS

A. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656. Use a color tinted material.

2.03 MANUAL VALVES

A. Brass Ball Valves:
   1. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. DynaQuip Controls.
      d. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
      e. Hammond Valve.
      f. Jamesbury; a subsidiary of Metso Automation.
      g. Jomar International, LTD.
      h. KITZ Corporation.
      i. Legend Valve.
      j. Marwin Valve; a division of Richards Industries.
      k. Milwaukee Valve Company.
      l. NIBCO INC.
      m. Red-White Valve Corporation.
      n. RuB Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig .
      c. CWP Rating: 600 psig .
      d. Body Design: Two piece.
      e. Body Material: Forged brass.
      f. Ends: Threaded or solder joint if indicated.
      g. Seats: PTFE or TFE.
      h. Stem: Brass.
      i. Ball: Chrome-plated brass.
      j. Port: Full [not reduced].

B. Plastic Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. American Valve, Inc.
      b. Asahi/America, Inc.
      c. Colonial Engineering, Inc.
      d. Fischer, George Inc.
      e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
      f. IPEX Inc.
      g. Jomar International, LTD.
      h. KBI (King Bros. Industries).
      i. Legend Valve.
      j. NIBCO INC.

k. Sloane, George Fischer, Inc.
l. Spears Manufacturing Company.
m. Thermoplastic Valves Inc.
n. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
a. Standard: MSS SP-122.
b. Pressure Rating: 200 psig .
c. Body Material: PVC.
d. Type: Union.
e. End Connections: Socket or threaded.
f. Port: Full.

2.04 PRESSURE-REDUCING VALVES

A. Water Pressure Regulators:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Cash Acme; a division of The Reliance Worldwide Corporation.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Honeywell International Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group; Wilkins Water Control Products.
2. Description:
a. Standard: ASSE 1003.
b. Body Material: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved.
c. Pressure Rating: Initial pressure of 150 psig .
d. End Connections: Threaded for NPS 2 and smaller.

2.05 AUTOMATIC CONTROL VALVES

A. Low Flow Drip Control Valves :
1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid. For flow ranges below 5 gpm.
2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Buckner; a division of Storm Manufacturing Group Inc.
b. Ceres Products Company.
c. Champion Irrigation Products.
d. Dig Corporation.
e. Greenlawn Sprinkler Company.
f. Hit Products Corporation.
g. Hunter Industries Incorporated.
h. Irritrol Systems.
i. Nelson, L. R. Corporation.
j. Netafim USA.

k. Olson Irrigation Systems.
l. Orbit Irrigation Products, Inc.
m. Rain Bird Corporation.
n. Superior Controls Co., Inc.
o. Toro Company (The); Irrigation Division.
p. Weathermatic.

2.06 AUTOMATIC DRAIN VALVES

A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig .

2.07 TRANSITION FITTINGS

A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Cascade Waterworks Manufacturing.
b. Dresser, Inc.; DMD Division.
c. Ford Meter Box Company, Inc. (The).
d. JCM Industries.
e. Smith-Blair, Inc; a Sensus company.
f. Viking Johnson.
2. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Metal to Plastic Transition Fittings at Point of Connection:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Harvel Plastics, Inc.
b. Spears Manufacturing Company.
2. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket or threaded end.

2.08 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.

B. Pressure Gages: ASME B40.1. Include 4-1/2-inch- diameter dial, dial range of two times system operating pressure, and bottom outlet.

C. Detectable Warning Tape: Provide detectable warning tape with “IRRIGATION LINE” clearly marked and a unique color.

2.09 QUICK COUPLERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hunter Industries Incorporated.
2. Nelson, L. R. Corporation.
3. Rain Bird Corporation.
4. Toro Company (The); Irrigation Division.

5. Weathermatic.

B. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap;

C. Key – Provide factory-fabricated brass one piece swiveling connector with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet. Provide one key per installed quick coupler with a minimum number of two.

2.10 RAIN SENSOR

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hunter Industries Incorporated.
2. Nelson, L. R. Corporation.
3. Rain Bird Corporation.
4. Toro Company (The); Irrigation Division.
5. Weathermatic.

B. Description: UL listed, UV stabilized plastic housing rain sensor with the following properties:
1. Hardwire installation
2. 2-5 minute time duration to system shut down
3. Time to reset should be less than 4 hours
4. Operating temperature range 32 – 130 degrees
5. 24 volt, 3amp
6. Matched to controller station
7. Selectable rain shut off indexes at 1/8”, ¼”, ½”. ¾” of rainfall

2.11 DRIP IRRIGATION SPECIALTIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Agrifim.
2. Aquarius Brands, Inc.
3. Buckner; a division of Storm Manufacturing Group Inc.
4. Dig Corporation.
5. Geoflow, Inc.
6. Hendrickson Bros.
7. Hit Products Corporation.
8. Irritrol Systems.
9. Maxijet, Inc.
10. NDS/Raindrip.
11. Netafim USA.
12. Olson Irrigation Systems.
13. Orbit Irrigation Products, Inc.
14. Rain Bird Corporation.
15. Roberts Irrigation Products, Inc.
16. Salco Products.
17. Toro Company (The); Irrigation Division.

B. In-line [inside pipe] Emitter Systems:
1. Tubing: PE or PVC; 1/2-inch minimum ID, UV resistant.
2. Emitter: In-pipe device .
a. Body Material: UV Resistant PE or Vinyl
b. Design Flow: .5 to 1.0 gph.
c. Spacings 12” to 18” oc..
d. Pressure compensating from 15-50 psi
e. Minimum operation pressure if 15 psi

f. Minimum filtration 120 mesh
g. Self flushing design
h. Includes an internal low pressure 2 psi check valve
i. Includes a non chemical physical or copper root barrier

C. On-line [on pipe] Emitter Systems:
1. Tubing: Black PE tubing UV resistant.
2. Emitter: Attached to pipe drip device .
a. Body Material: UV Resistant PE or Vinyl
b. Design Flow: .5 to 2.0 gph.
c. Pressure compensating from 7-50 psi
d. Minimum operation pressure if 15 psi
e. Minimum filtration 120 mesh
f. Self flushing design
g. Includes an internal low pressure 1.5 psi check valve

D. Pop Up Micro Spray:
1. Tubing: PE or PVC; 1/4-inch minimum ID, UV resistant.
2. 8” pop up microspray emitter:.
a. Body Material: UV Resistant PE or Vinyl
b. Design Flow: .5 to 1.0 gph.
c. Operating Pressure: 15-35PSI
d. 5’ wetting diameter, flat tragectory
e. Pressure compensating from 15-50 psi

E. Application Pressure Regulators: Brass or plastic housing, NPS 3/4 , with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig .

F. Filter Units: Plastic housing with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.
1. Provide screening to 120 mesh size.
2. Minimum size 3/4”
3. Flow Range 1-12 gpm
4. maximum pressure 140 psi
5. Polyamide staking ring type filter

G. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

H. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.12 CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Buckner; a division of Storm Manufacturing Group Inc.
2. Champion Irrigation Products.
3. Hit Products Corporation.
4. Hunter Industries Incorporated.
5. Irritrol Systems.
6. K-RAIN Manufacturing Corporation.
7. Nelson, L. R. Corporation.
8. Netafim USA.
9. Orbit Irrigation Products, Inc.
10. Rain Bird Corporation.
11. Superior Controls Co., Inc.

12. Toro Company (The); Irrigation Division.
13. Weathermatic.

B. Description:
1. General: Time clocks must provide the following features:
a. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily
b. A minimum of programming three fully independent programs with four start times per program.
c. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation
d. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 120 minutes. Include switch for manual or automatic operation of each station
e. Quantity of stations equal to the zones required plus 4 empty zones.
f. Rain Sensor: Adjustable from one to seven days, to shut off water flow during rain
g. Non-volatile memory for holding programs during power outages
h. 120 volt input, 24 VAC output
i. Control Transformer: 24-V secondary, with primary fuse
j. Surge Protection: Metal-oxide-varistor type on each station and primary power
k. With a cistern, pump start capability
l. Hand held remote included with system
m. Lockable cabinet with two matching keys.

2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof and provision for grounding.
a. Body Material: Enameled-steel sheet metal or Stainless-steel sheet metal
b. Mounting: Surface type for wall.

3. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
4. Concrete Base: Reinforced precast concrete not less than [36 by 24 by 4] inches thick. Include opening for wiring.

2.13 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Armorcast Products Company.
b. Carson Industries LLC.

c. Nationwide Plastics, Inc.
d. NewBasis.
e. Oldcastle, Inc.
f. Orbit Irrigation Products, Inc.
g. USFilter/Plymouth Products, Inc.

2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
   a. Size: As required for valves and service.
   b. Shape: Round and rectangular
   c. Sidewall Material: Structural foam plastic.
   d. Cover Material: Structural foam plastic
   e. UV resistant
   f. Stainless steel screw lock
   g. Color: black

B. Drainage Backfill: #57 stone.

PART 3 EXECUTION

3.01 PREPARATION

A. Carefully mark out the extent of lawn versus planting beds to avoid spray overlap.
B. Examine the site compared to the system design and notify the Architect of changes.
   1. Submit design changes to the Architect if revisions to the design are warranted
C. Verify existence of required sleeving.
D. Store pipe and fitting for project in an area that will not introduce dirt and debris into the interior.

3.02 PIPING INSTALLATION

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
C. Install piping free of sags and bends.
D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
E. Install fittings for changes in direction and branch connections.
F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.
G. Install expansion loops in control-valve boxes for plastic piping.
H. Lay piping on solid subbase, uniformly sloped without humps or depressions.
I. Install PVC piping in dry weather when temperature is above 40 deg F . Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.
J. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install below ground in control-valve boxes.
K. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.
L. Install 4 inch diameter sleeves made of Schedule 80 PVC pipe (vehicular loads) and Schedule 40 PVC pipe (pedestrian loads) and socket fittings, and solvent-cemented joints. Extend 12 inches beyond edge of walk and cap ends. Provide flag indicating location and update contractor record set with final installed location.

M. Install piping in sleeves under parking lots, roadways, and sidewalks. Avoid fittings within sleeves.

N. Install transition fittings for plastic-to-metal pipe connections according to the following:
   1. Under pedestal paver Piping:
      a. NPS 1-1/2 and Smaller: Plastic-to-metal transition fittings.
      b. NPS 2 and Larger: AWWA transition couplings.

3.03 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

E. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   3. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.04 VALVE INSTALLATION

A. Isolation valves: Install isolation valves with handles oriented to surface.

B. Pressure-Reducing Valves: Install in boxes for automatic control valves. Install full-size valved bypass.

C. Automatic Control Valves: install according to manufacture’s recommendations with manual adjustment handles oriented to the surface.

D. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.05 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers in final grades at manufacturer's recommended heights.

C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries such as curbs and walks unless otherwise indicated.

3.06 QUICK COUPLER INSTALLATION

A. Install quick coupler as per manufacturers’ recommendations at a height below mower damage level.

B. Install approximately 6” by 6” by 6” concrete collar underground, covered by 1” of soil.

C. Paint exposed plastic parts black.

3.07 RAIN SENSOR INSTALLATION

A. Hardwire connection from time clock to sensor.

B. Place in an open area with no overhang as approved by the landscape architect or as shown on the plan.

C. Installation should be neat with organized wiring.

3.08 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install area connection tubes with 3” of cover and with galvanized stakes as needed.
   1. For each zone provide loop back to within 10’ of the first emitter.

B. Install the number of drip emitter per plant according to TABLE 1 – DRIP SYSTEM PERFORMANCE REQUIREMENTS

C. For large shrubs, use drip line with internal emitters on “T” loops from main line.

D. For container shrubs choose drip line with internal emitters for regularly spaced shrubs and drip line with external emitter for irregularly spaced shrubs.

E. For mass plantings of small containers or plugs, use a grid of drip tube with internal emitters.

F. Install drip tubes as follows:
   1. Install on ground. Stake with galvanized stakes as needed to maintain contact.
   2. Drip tubing should be placed on the root ball, 3” from the edge and exposed.
   3. External emitters should be exposed to view.
   4. For container shrubs place beneath the mulch on the root ball.
   5. For grid layout, use a matching spacing to the planting.

G. Install application pressure regulators and filter units in piping near zone valves below ground in boxes. Orient the regulators to assist with maintenance.

3.09 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install interior controllers at eye level on wall.
   1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install control cable in same trench as irrigation piping and at least 2 inches beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas. Install warning tape during backfill operation.

3.10 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Section "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

C. Connect wiring between controllers and automatic control valves.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Brand each valve box where isolation valve, automatic control valves, pressure regulator valve, or filter is housed with a unique name that appears on the time clock and the as-built drawings.
   1. Text: Minimum ½’ letters branded into plastic valve box housing.
      a. Turf Valves – Use 1-50
      b. Drip Valves – Use 51-99
      c. Valves, Pressure Regulators & Other Equipment - Use 100 and above

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Division 31 Section "Earth Moving" for warning tapes.

3.12 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. System Main Feed & Main Line Leak Test: After installation, charge system and test for leaks with a pressure indicator over a 24 hour period. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Test spray heads for too little or too much pressure. Make adjustments in the system, including installing pressure compensation devices or boosting overall system pressure to provide a functioning system.

B. Any irrigation system or product will be considered defective if it:
   1. Does not pass tests and inspections.
   2. Does not provide manufacturer’s recommended pressures throughout the system
   3. Does not provide complete separation of grass and planting areas
   4. Does not provide matched precipitation rates throughout the lawn
   5. Does not provide drip system delivery target rates for plant types.
   6. Sprays water onto pavements, buildings, or signage.
   7. Does not provide for easy maintenance as follows:
      a. Ball valves, filters, regulators are poorly oriented for hand access
      b. Automatic Valves are poorly oriented for access
      c. Irrigation equipment is installed at a grade that would encourage damage from mowers

C. Defective irrigation systems or components shall be repaired at no cost to the Owner.

3.13 FLUSH OUT CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

B. Clean or replace all filters.

3.14 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that controllers are installed and connected according to the Contract Documents.
   3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.15 ADJUSTING

A. Provide at least three programmed time schedules.
   a. One is for immediate post planting where the system is run at high rates for a short duration.
   b. Second is for a longer term establishment period, where distribution rates are reduced but still higher for plant establishment.
   c. Third is a long term summer schedule distributing about 1” of precipitation to lawn areas per week and 70 gallons per week to shrubs.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices so they will be flush with finish grade or as recommended by the manufacturer.

D. Adjust drip system to provide gallons per week delivery targets by adding and subtracting emitters.

3.16 DEMONSTRATION

A. Train Owner's maintenance personnel by providing the following instruction:
   1. Review the as-built materials with the owner
   2. Demonstrate how to program the clock.
   3. Demonstrate how to adjust heads
   4. Demonstrate how to clean filters and pressure regulation
   5. Review the site components of the system, identify valve boxes

3.17 TRAINING

A. Contractor to provide training for operation and maintenance of all equipment.

END OF SECTION

SECTION 32 92 00 – TURF AND GRASSES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Seeding.
   2. Hydroseeding.
   3. Sodding.
   4. Grass Paving.

1.02 DEFINITIONS

A. Final Acceptance: The proper installation of seed, sod, and meadow with final grades, mulch and irrigation functioning (if provided) with no indication of widespread plant death. For seeded and meadow areas, the seed must show germination with green shoots visible. It is possible to grant Final Acceptance to portions of the site without total project completion however all construction activities must be completed in the requested area.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

E. Planting Soil: The prepared earth [existing or imported as specified herein] used to backfill lawn or sod areas.

F. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

G. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

H. Turf: A groundcover established from either lawn type seeds, lawn type sod or meadow seeds.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

1.04 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
   1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

B. Qualification Data: For qualified landscape Installer.

C. Product Certificates: For soil amendments, fertilizers, pesticides, herbicides, and other products to be used, from manufacturer.

D. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit at time of Final Acceptance.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
   1. Professional Membership: Installer shall be a member in good standing of National Association of Landscape Professionals, the NC Landscape Contractors' Licensing Board, or AmericanHort.
   2. Experience: Five years' experience in turf installation.
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the following:
      a. National Association of Landscape Professionals Landscape Industry Certified Exterior Technician.
      b. National Association of Landscape Professionals Landscape Industry Certified Horticultural Technician.
      c. Actively licensed by the North Carolina Landscape Contractors' Licensing Board.
      d. Four-year degree in horticulture, landscape architecture or agronomy.

B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: For each un-amended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
   1. Test soil components of Planting Soils Type A, B, C.
   2. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
   3. Test shall include mechanical analysis of sand, silt and clay components.
   4. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
   5. Soil tests shall include the following information:
      a. Percentage of sand, silt and clay.
      b. Cation exchange capacity.
      c. Percent of organic matter.
      d. Stated recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
      e. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation"

in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

C. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.07 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Final Acceptance. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

Grass Type	Fall Season	Spring Season
Warm season grasses	Sept 1 to Oct 15	May 15-July 15

B. Water Source:
   1. The Contractor shall provide water for:
      a. The construction period until Final Acceptance for the last phase of work.
      b. Final Acceptance for the last phase of work through the maintenance period.
   2. The Contractor shall supply watering labor as follows:
      a. The construction period until Final Acceptance for the last phase of work.
      b. Final Acceptance for the last phase of work through the maintenance period.

1.08 MAINTENANCE

A. Initial Maintenance Service for Lawns sod and seed areas: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after lawns are installed and continue until plantings are acceptably healthy, well established, and deemed satisfactory per Part 3; but for not less than the Construction Maintenance Period below.
   1. Construction Maintenance Period: 12 months. The Construction Maintenance Period will begin from the date of Final Acceptance for the last phase of work. Partial areas of turf deemed satisfactory per Part 3 require continued maintenance until all areas are deemed satisfactory per Part 3 and until final date of Construction Maintenance Period; whichever elapses last.
   2. Landscape Maintenance Period - The Landscape Maintenance Period will begin from the date of the Construction Maintenance period described above lapses.

PRODUCTS

1.09 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species: Seed of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:

Lawn Type	Seed Mix	Notes
Warm Season	Hybrid Bermuda	

1.10 TURFGRASS SOD

A. Turfgrass Sod: Number 1 Quality/Premium, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

B. Turfgrass Species: Tiffway 417 Bermudagrass

C. Meadow Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ratio of not less than two parts seed carrier to one part seed.

1.11 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Provide lime in form of ground dolomitic limestone or calcitic limestone depending on soil test.

1.12 ORGANIC SOIL AMENDMENTS

A. Soil Conditioner: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 70 percent of dry weight.
   2. Sources: Agricultural, bark, biosolids; municipal compost; or source-separated or compostable mixed solid waste.
      a. Free of toxic materials to plant growth
      b. Free of weed seeds.

1.13 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

1.14 PLANTING SOILS

A. Planting Soil Type A: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
   1. Depth of soil conditioner to mix in Planting Soil: 3/8”to 4”.
   2. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. consult soil test.
   3. Weight of dolomitic limestone per soil test.

B. Planting Soil Type B: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth by mechanical screening.
   1. Supplement with approved Planting Soil Type C when quantities are insufficient.
   2. Mix existing, native surface topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
   3. Depth of soil conditioner to mix in Planting Soil: 3/8”to 4”.
      a. Weight of Slow-Release Fertilizer as per soil test.
      b. Weight of dolomitic limestone as per soil test.

C. Planting Soil Type C: Imported sandy loam topsoil formed under natural conditions blended with organic matter. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
   1. Depth of soil conditioner to mix in Planting Soil: 3/8”to 4”.
   2. Weight of Slow-Release Fertilizer as per soil test
   3. Weight of dolomitic limestone as per soil test.

D. Soil Type D Structural Soil: Imported manufactured structural soil containing components of expanded slate and organic matter. Verify suitability of native surface topsoil to produce viable planting soil.
   1. Ratio of soil conditioner to Planting Soil by Volume: 1:6.
   2. Weight of Slow-Release Fertilizer as per soil test
   3. Weight of dolomitic limestone as per soil test.

1.15 MULCHES

A. General: The Contractor shall select the mulching products that best suit the grass seed selected. Choose from the following mulches:
   1. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
   2. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

B. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

1.16 PESTICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

1.17 GRASS-PAVING MATERIALS

A. Grass Paving: Cellular, made from recycled plastic, non-biodegradable mats, designed to contain small areas of soil and allow an 80,000 lbs fire truck loading and general service traffic. Include manufacturer's recommended anchorage system for slope conditions.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. AirPave by AirField Systems. (http://www.airfieldsystems.com/grass-pave/)

b. Invisible Structures, Inc.; Grasspave2. (http://www.invisiblestructures.com/grasspave2.html)

c. NDS, Inc. Tufftrack or Grasspave (

d. Presto Products Company, a business of Alcoa; Geoblock Porous Pavement System. (http://www.prestogeo.com/geoblock_porous_pavement)

e. RK Manufacturing, Inc.; Grassy Pavers. (http://www.grassypavers.com/)

B. Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.

C. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.

D. Proprietary Growing Mix: As submitted and acceptable to Architect.

E. Sandy Loam Soil Mix: Naturally occurring sandy loam topsoil containing 60% sand, 35% silt and 5% clay, 5% by volume organic matter and free of weed seed and deleterious materials to plant growth.

F. Soil for Paving Fill: Planting soil B as specified.

PART 2 EXECUTION

2.01 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance. Notify the Architect immediately and do not start landscape construction operations if:
1. Grades or site features do not match the design.
2. There is ponding or areas that do not appear to drain
3. The subsoil contains foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
4. If the soils are frozen or moist beyond that required to produce optimal working conditions.
5. Excessively dry soil that is not workable and which is too dusty.
6. If the subsoil is over compacted.
7. If irrigation main and lateral lines have not been installed.
8. If irrigation main or lateral line trenches have not been compacted.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Erosion Control Seeding Contamination – Evaluate the erosion control seeding used and confirm that potential seed sources will not interfere with the establishment of seeded lawns or meadows. Confer with the General Contractor on usage of erosion control seeding and potential threats to establishing lawns or meadows.

2.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.
3. Protect areas that should not receive seed such as planting beds.

2.03 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches.
1. General

a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
b. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, trash, and other extraneous matter.
c. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
d. Reduce elevation of planting soil to allow for soil thickness of sod.

2. Spread planting soil to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
3. Thoroughly blend planting soil with organic amendments off-site before spreading
4. Apply lime and fertilizers on surface, and thoroughly blend planting soil.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.
a. Note any areas on the plan that indicate tree root zones. These areas may require the use of hand tools.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

2.04 PREPARATION FOR GRASS-PAVING MATERIALS

A. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions, compact subgrade as specified in paving-material manufacturer's written instructions..

B. Install base course and/or sand course as recommended by paving-material manufacturer for site conditions; comply with details shown on Drawings. Compact according to paving-material manufacturer's written instructions.

C. Install paving mat and fasten according to paving-material manufacturer's written instructions.

D. Before planting, fill cells of paving mat with sandy loam soil mix and compact according to manufacturer's written instructions.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

2.05 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph . Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
1. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at the following rates:

Hybrid Bermuda	2 lbs per 1000 sf

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.

E. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a rate to form a continuous blanket 1 inch in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
   1. Bond straw mulch by spraying with non-asphalt emulsion at a rate to resist wind and erosion. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

F. Protect seeded areas from hot, dry weather or drying winds by applying hydromulch within 4 hours after completing seeding operations.

2.06 HYDROSEEDING – TWO STEP PROCESS

A. Mix specified seed, commercial fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
   1. Mix slurry with nonasphaltic tackifier.
   2. Spray-apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

2.07 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
   1. Lay sod across angle of slopes exceeding 1:3.
   2. Anchor sod on slopes exceeding 1:6 or in the bottom of swales with steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

2.08 PLUGGING

A. Plant plugs in holes or furrows, spaced 12 inches apart in both directions. On slopes, contour furrows to near level.

2.09 SPRIGGING

A. Plant freshly shredded sod sprigs in furrows 1 to 1-1/2 inches deep. Place individual sprigs with roots and portions of stem in moistened soil, 6 inchesapart in rows 10 inches apart, and fill furrows without covering growing tips. Lightly roll and firm soil around sprigs after planting.

B. Broadcast sprigs uniformly over prepared surface at a rate of [10 cu. ft./1000 sq. ft.] <Insert rate> and mechanically force sprigs into lightly moistened soil.
   1. Spread a 1/4-inch- thick layer of [compost mulch] [peat mulch] [planting soil] on sprigs.
   2. Lightly roll and firm soil around sprigs after planting.
   3. Water sprigs immediately after planting and keep moist by frequent watering until well rooted.

2.10 TURF RENOVATION

A. Renovate existing turf.

B. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
   1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
   2. Install new planting soil as required.

C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

E. Mow, dethatch, core aerate, and rake existing turf.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 4 inches.
   1. Confirm that there are no protected root zone areas that would require special procedures.

I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.

J. Apply seed or sod as shown on the plans and as required for new turf.

K. Water newly planted areas and keep moist until new turf is established.

2.11 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
   1. Repair turf as necessary because of settling, erosion or settlement or other processes.
   2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
   3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain irrigation systems, temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
   1. Mow bermudagrass to a height of 1 inch.

D. Turf Postfertilization: Apply fertilizer after initial mowing and when grass is dry.
   1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

2.12 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:
   1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 3 by 3 inches.
   2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
   3. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
   4. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

2.13 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

2.14 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION

SECTION 32 93 00 - PLANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Plants.
2. Planting soils.
3. Landscape edgings.

1.02 REFERENCES

1. ANSI/SPRI VR-1 2011 “Procedure for Investigating Resistance to Root Penetration on Vegetative Roofs”
2. International Concrete Repair Institute (ICRI) Concrete Surface Profile (CSP) Scale.

1.03 DEFINITIONS

A. Final Acceptance: The proper installation of plant material with final grades, mulch and irrigation (if provided) functioning with no indication of widespread plant death. It is possible to grant Final Acceptance to portions of the site without total project completion however all construction activities must be completed in the requested area.

B. Backfill: The planting soil used to replace or the act of replacing earth in an excavation.

C. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

D. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

E. Finish Grade: Elevation of finished surface of planting soil.

F. Green Roof -- An area of planting/landscaping, built up on a waterproofed substrate at any level that is separated from the natural ground by a man-made structure.

G. Intensive Green Roof -- Landscaping requiring regular maintenance, consisting of deeper growing media depths (see plans) with a wider variety of plant species possible including shrubs and small trees.

H. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

I. Planting Area: Areas to be planted.

J. Planting Soil: The prepared earth [existing or imported as specified herein] used to backfill planting areas or to create planting beds.

K. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

L. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

M. Stem Girdling Roots: Roots that encircle the stems (trunks) or main roots of trees below the soil surface.

N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

O. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

P. Environmental Conditions: Physical, chemical, and biotic factors affecting ecological community and ability for plants to survive.

Q. Detrimental Conditions: Environmental conditions harmful to the health of proposed plants that can be corrected through supplemental site improvements. Harmful conditions include, but shall not be limited to the following: poor soil, poor drainage, or contaminated soil.

1.04 ACTION SUBMITTALS

A. Samples for Verification: For each of the following:
   1. Mulch: A 1-quart volume of each mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
   2. Decorative Stone: 1 quart volume of each decorative stone required, in sealed plastic bags labeled with source of stone. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of color, texture, and makeup of the material.
   3. Sand Media: 1 quart volume of sand media, in sealed plastic bags labeled with source of sand. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of color, texture, and makeup of the material.
   4. Growing Media: 1-quart volume of each growing medium, in sealed plastic bags labeled with content and source. Each Sample shall be typical of the lots of growing media to be furnished. Provide an accurate representation of texture and composition
   5. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
   6. Root Barrier: 12 by 12 inches.
   7. Separation Geotextile: 12 by 12 inches.

B. Soil Analysis: For each un-amended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
   1. Test soil components of Planting Soils Type A, B, C and Vegetated Roof Soils.
   2. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
   3. Test shall include mechanical analysis of sand, silt and clay components.
   4. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
   5. Soil tests shall include the following information:
      a. Percentage of sand, silt and clay.
      b. Cation exchange capacity.
      c. Percent of organic matter.
      d. Stated recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
      e. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such

problem materials are present, provide additional recommendations for corrective action.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For soil amendments, fertilizers, pesticides, herbicides, and other products to be used, from manufacturer.

C. Substitutions: The Contractor shall provide the products specified. Changes must be made by written submittal with reason and alternate suggestion.

D. Environmental Conditions: Prior to contract acceptance by Contractor, submit written description of environmental conditions preventing compliance with warranty.
   1. As applicable, submit detrimental conditions and/or substitutions submittals.

E. Detrimental Conditions: Per encounter, submit written description of detrimental conditions with recommendation for correcting condition. Include cost estimate.

F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of all plants during a calendar year. Submit at time of Final Acceptance.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.
   1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or the American Nursery and AmericanHort.
   2. Experience: Five years' experience in landscape installation.
   3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the following:
      a. National Association of Landscape Professionals Landscape Industry Certified Exterior Technician.
      b. National Association of Landscape Professionals Landscape Industry Certified Horticultural Technician.
      c. Actively licensed by the North Carolina Landscape Contractors’ Licensing Board.
      d. Four-year degree in horticulture, landscape architecture or agronomy.

B. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
   1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
   2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

C. Plant Pre-Approvals: Utilize the following methods for plant selection.
   1. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to the Project that is larger than 5-gallon plants. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.
   2. Plant Tagging: The Architect will require nursery plant tagging for all trees.

D. Plant Pre-Approvals: Utilize the following methods for plant selection.

E. Additional Plant Material Observation: Architect may observe plant material either at site before planting or once installed for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

F. Substitutions: Substitutions will be permitted only upon submission of proof that a specified plant is not obtainable and with written approval of proposed substitution by Landscape Architect.
   1. Contractor shall propose the use of the nearest obtainable variety of the plant having the same essential characteristics that is equal to or greater in size to original specified plant.

G. Detrimental Conditions: The contractor shall notify the Owner and Landscape Architect in writing of all conditions considered detrimental to growth of plant material. State condition and submit proposal including costs for correcting condition.

H. Preinstallation Conference: Conduct conference at Project site.
   1. The following individuals must be present:
      a. Contractor's site representative responsible for the Landscape Installer's work
      b. The Landscape Installer's branch manager [or Owner] and job estimator.
      c. The Project supervisor who will be directly responsible for fieldwork and/or paperwork.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

C. Do not prune trees and shrubs before delivery.

D. Protect bark, branches, and root systems from sunscald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball or container.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

H. If plants are stored for over 24 hours provide the following:
   1. Set balled stock upright on ground and cover ball with soil, peat moss, sawdust, or other acceptable material to prevent wind, cold, or heat damage to the roots.
   2. Provide shade to shade requiring trees and shrubs.

3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.08 PROJECT CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:
   1. Notify Owner and Architect no fewer than two days in advance of proposed interruption of each service or utility.
   2. Do not proceed with interruption of services or utilities without Architect's written permission.

C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Final Acceptance.
   1. Spring Planting: Feb 15 - April 15.
   2. Fall Planting: Sept 15 – Jan 1.

D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated or acceptable to Landscape Architect.
   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

F. Under no circumstances should work proceed prior to establishment of appropriate grades.

G. Water Source:
   1. The Contractor shall provide water for:
      a. The construction period until Final Acceptance for the last phase of work.
      b. Final Acceptance for the last phase of work through the maintenance period.
   2. The Contractor shall supply watering labor as follows:
      a. The construction period until Final Acceptance for the last phase of work.
      b. Final Acceptance for the last phase of work through the maintenance period.

H. Unusual Field Conditions: It is the Contractor’s responsibility to communicate to the Architect unusual field conditions found at the project site before and during construction. The presence of unusual field conditions such as wind, wetness, soil issues, invasive weeds, will require the Contractor take note and advise the Architect on how best to remedy the discovery.

1.09 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
      b. Structural failures including plantings falling, blowing over or settling out of plumb.
      c. Faulty performance of tree stabilization, edgings, tree grates, or subdrainage.

d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods from Date of Final Acceptance:
   a. Trees, Shrubs, Vines, Ornamental Grasses, Ground Covers, Biennials, Perennials, and Other Plants, metal edges, decorative mulches, landscape drainage features, landscape grading: 12 months.
3. Inspections:
   a. Perform maintenance checkups at 3-month intervals to verify that plant material is being properly maintained. Notify Owner in writing of any deficiencies.
   b. Eleven months into warranty period, request in writing a year-end inspection by Owner and Landscape Architect.
4. Include the following remedial actions as a minimum:
   a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
   b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
   c. There will be no limitation on replacements of each plant except for losses or replacements due to species intolerance of environmental conditions.
      1) Contractor shall notify Landscape Architect in writing of any concerns related to species intolerance of environmental conditions prior to purchase of plant material; otherwise, purchased plant material will be accepted by Contractor as tolerant of environmental conditions. Detrimental conditions shall be corrected prior to installation of plant material and shall not be considered grounds for warranty exclusion.
   d. Provide extended warranty for period equal to original warranty period, for replaced plant material. As required, continue extended warranty until leaf out to ensure health of replaced material. Plants shall be deemed dead if leaf out does not occur prior to end of spring.
5. All replacements shall be plants of the same kind as originally planted and shall be of size equal to that attained by adjacent plants of the same kind at the time replacement is made. They shall be furnished and planted as specified herein.
6. Removal and replacement shall be at no cost to the Owner.

1.10 MAINTENANCE SERVICE

A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than Construction Maintenance Period below. Maintenance requirements at 12-month warranty review noted in Part 3 are exceptions when a shorter Construction Maintenance Period is specified below.
   1. Construction Maintenance Period: 12 months. The Construction Maintenance Period will begin from the date of Final Acceptance for the last phase of work. Partial areas of the site substantially completed require continued maintenance until all areas of the site are deemed substantially complete and until final date of Construction Maintenance Period.
   2. Landscape Maintenance Period - The Landscape Maintenance Period will begin from the date of the Construction Maintenance period [described above] lapses.

B. For Mechanized Tree Spade Trees: Provide 12 months of watering by refilling slow release water bags from the date of installation.

PART 2 PRODUCTS

2.01 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
   1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.
   2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
   3. Provide trees from active, consistently aged specimens.
   4. Unless directly specified, provide only trees that are genetic clones of the requested variety.

B. Select Balled and Burlapped material from nurseries who utilize root pruning practices and have a systematic approach to hardening off newly dug material.

C. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

D. Provide small trees and shade trees that are grown on their own roots, not utilizing grafting or budding techniques (unless directed in the plant list).

E. Provide container plant material that is free from circling roots or pot bound conditions.

F. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

G. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.

H. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

2.02 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Provide lime in form of ground dolomitic limestone.

2.03 VEGETATED ROOF PREFABRICATED DRAINAGE COURSE

A. Composite drainage systems consisting of a three-dimensional, crush-proof, drainage core and filter fabric.

2.04 ORGANIC SOIL AMENDMENTS

A. Soil Conditioner: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Pine bark soil conditioner: finely ground, well composted, pine bark mulch with a maximum particle size of ¼”.
   2. Organic Matter Content: 70 percent of dry weight.
   3. Sources: Agricultural, bark, biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

a. Free of toxic materials to plant growth

b. Free of weed seeds.

2.05 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

B. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory. Several different blends may be necessary to meet the requirements.

2.06 PLANTING SOILS

A. Planting Soil Type A: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Sandy loam texture. Mix surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
1. Screen to remove extraneous materials.
2. Ratio of soil conditioner to Surface Soil by Volume: 1:5.
3. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. consult soil test.
4. Weight of dolomitic limestone per soil test.
5. Supplement with Soil Type C when quantities are insufficient.

B. Planting Soil Type B: Existing [found on site], native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Sandy loam texture. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth by mechanical screening.
1. Screen native material to remove extraneous materials
2. Supplement with approved Planting Soil Type C when quantities are insufficient.
3. Mix existing, native surface topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
a. Ratio of soil conditioner to Topsoil by Volume: 1:10.
b. Weight of Slow-Release Fertilizer as per soil test.
c. Weight of dolomitic limestone as per soil test.

C. Planting Soil Type C: Imported sandy loam topsoil formed under natural conditions blended with organic matter. Sandy loam texture. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
1. Ratio of soil conditioner to Topsoil by Volume: 1:10.
2. Weight of Slow-Release Fertilizer as per soil test
3. Weight of dolomitic limestone as per soil test.

D. Planting Soil Type D: Lightweight Intensive Roof Top Media. Refer to Architectural.

2.07 MULCH

A. Mulch: Well-composted, stable, and weed-free organic matte, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 2 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Triple shredded hardwood
2. Color: Natural.

2.08 DECORATIVE STONE

A. Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:

TYPE	SIZE	COLOR	DESCRIPTION
Type A	3”- 9”	Browns, grays, mauve, occasional tan	Rounded River Stone
TYPE C – ALONG BUILDING	1”-3”	Black/Gray	Virginia Slate Chips by Marshall Stone 19730 Virgil H. Goode Hwy Rocky Mount, VA 24151 (540) 483-2737 or equivalent slate chip product upon approval by Landscape Architect; angular, uniform
TYPE D – ALONG BUILDING	3 - 5”	Black/Gray	Virginia Slate Chips by Marshall Stone 19730 Virgil H. Goode Hwy Rocky Mount, VA 24151 (540) 483-2737 or equivalent slate chip product upon approval by Landscape Architect; angular, uniform

2.09 METAL EDGING

A. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
   1. Edging Size: 1/4 inch wide by 5 inches deep.
   2. Stakes: Tapered steel, a minimum of 15 inches long.
   3. Accessories: Standard tapered ends, corners, and splicers.
   4. Finish: Standard paint
   5. Paint Color: Black.

2.10 SUB DRAINAGE

A. Drainage pipe: 4” black corrugated slotted PE pipe pre-wrapped in a geo-textile fabric capable of filtering clay soil from migrating into the pipe.

B. Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTMD448.

2.11 MISCELLANEOUS PRODUCTS

A. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

2.12 HERBICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.13 PESTICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
   1. Use pesticides on an as-needed basis.

2.14 TREE STABILIZATION MATERIALS

A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood Stakes and Guys:
   1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
   2. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
   3. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
   4. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

B. Below Grade Root-Ball Stabilization Materials:
   1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated; stakes pointed at one end.
   2. Wood Screws: ASME B18.6.1.

2.15 SAND MEDIA

A. Sand media information as stated on plans.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
   1. Verify that subgrades are correct prior to spreading topsoil or spreading amendments.
   2. Conduct water percolation tests to verify that planting depths and drainage will meet the needs of the plants that have been selected. Inform the Architect of any drainage issues.
   3. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   4. Along roadways and in landscape islands, remove gravel and asphalt from landscape beds.
   5. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
   6. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   7. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.03 GENERAL REQUIREMENTS FOR ALL PLANTING TYPES

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

E. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.

1. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
2. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
3. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
4. Maintain supervision of excavations during working hours.
5. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
6. If subdrainage is shown on Drawings or required under planting areas, insure contact between the root ball and subdrain pipe.

F. After excavation examine the area for potential drainage difficulties matched to plant varieties and inform the Architect of potential poorly drained areas. Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits. Discuss variations in the depth of planting with the Architect prior to planting.

G. Fill excavations with water and allow it to percolate away before positioning trees and shrubs.

H. Set out and space plants according to the planting plans and notes in even rows with triangular spacing unless otherwise indicated.

I. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

J. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

K. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

L. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

M. Backfill plants with the materials and methods indicated in the Tables below and with the following instructions:

1. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
2. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
3. Continue backfilling process. Water again after placing and tamping final layer of soil.

N. Vegetated Roof plants:

1. Perform planting according to vegetated roof assembly manufacturer's written instructions.
2. Do not place growing medium or plants during frozen, wet, or muddy conditions.
3. Suspend spreading, grading, and planting operations during periods of excessive moisture until the moisture content in growing medium reaches acceptable levels to attain the required results.
4. Uniformly moisten an excessively dry growing medium that is too dusty or unworkable.
5. Plant the outer edges of each planting group following the bed outline according to the plan. Once a satisfactory matched outer shape is obtained, fill the center of each area with plants according to the plan and spacing notes. See plans for plant quantities and types.

3.04 MASS PLANTING AREA REQUIREMENTS

A. Preparation - Loosen area of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 1

PLANTING TYPE	TREATMENT AREA	SOIL TREATMENT	BACKFILL FOR EXCAVATION
Shrub and Ground-cover masses	entire planting area	Loosen 8” deep	Use Planting Soil A OR B
Mass perennials	entire planting area	Loosen 8” deep	Use Planting Soil A OR B

1. Apply slow release fertilizer and amendments directly to grade before loosening.
2. Thoroughly mix amendments and soil to the depths indicated in Table 1 to produce a uniform, loose, friable planting bed.
3. Soil generated from excavations may be used after properly amended as specified.

3.05 MASS PLANTING AREA REQUIREMENTS

A. Preparation - Loosen subgrade of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 2

PLANT TYPE	TREATMENT AREA	SUBSOIL TREATMENT	EXCAVATION BACKFILL	PLANTING SOIL* DEPTH

Shrub and Ground-cover masses	entire planting area	Loosen 8” deep	Use Planting Soil*	6”
Mass perennials	entire planting area	Loosen 4” deep	Use Planting Soil*	6”
* Planting Soil Type B, C Vegetated Roof– see plans				

1. Spread planting soil to a depth indicated in Table 2 but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet. Mix planting soil with the subsoil to form an uneven soil horizon line.
2. Subsoil removed from excavations may not be used as planting soil.

3.06 SOLITARY TREES AND SHRUBS PLANTING REQUIREMENTS

A. Preparation - Loosen area of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 3

	Treatment area	Soil treatment	Backfill from excavation
Solitary Trees	10’ wider than the root ball	Loosen 12” deep	Use Planting Soil TYPE A
Solitary Shrubs	10’ wider than the root ball	Loosen 12” deep	Use Planting Soil TYPE A

1. Soil generated from excavations may be used after properly amended as specified.

3.07 SOLITARY TREES AND SHRUBS PLANTING REQUIREMENTS

A. Preparation - Loosen area of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 4

	Treatment area	Subsoil treatment	Backfill from excavation	Planting Soil * depth in treatment area
Solitary Trees	10 wider than the root ball	Loosen 12” deep	Use Planting Soil*	12”
Solitary Shrubs	10 wider than the root ball	Loosen 12” deep	Use Planting Soil*	8”
* Planting Soil Type B,C Vegetative Roof– see plans				

B. Subsoil removed from excavations may not be used as planting soil.

3.08 MECHANIZED TREE SPADE PLANTING

A. Supply trees as indicated in the plant list as harvested local trees.

B. The Architect shall tag all trees to be locally harvested with tree spade techniques.

C. Trees shall be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than the manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.

D. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.

E. Cut exposed roots cleanly during transplanting operations.

F. Use the same tree spade to excavate the planting hole as was used to extract and transport the tree.

G. Plant trees as shown on Drawings, with the following procedures :

1. Lower trees without damaging trunk or major branches
2. Fit the root ball into the hole leaving a minimum of gap between the root ball and hole.
3. Fill the remaining gap with a 70% sandy loam topsoil, 30% organic matter and fertilizer blend. Use water to carry mixture to the bottom of the excavation to insure the gap is full. Allow to drain and return the next day and repeat as necessary until all gaps are filled.
4. Stake the tree with appropriate cabling systems and insure the tree is plumb.
5. Mulch the tree planting area.

H. Where possible, orient the tree in the same direction as in its original location.

I. Supply one slow release watering bag per 4.5” caliper of tree.

3.09 PLANTING IN TREE PITS

A. Excavate tree pits according to the details, discard the excavated material.

B. Install drainage and gravel sumps as shown in the details

C. Contact the Architect for and inspection of results prior to proceeding.

D. Once approved, back fill the planter pits with Planter Soil as indicated on the drawings

E. Plant the plant material as indicated on the drawings. Set the crown so it is a maximum of 1” below the bottom of the tree grate. Install root stabilization.

F. Install material to appropriate depths, leaving room for the final application of mulch.

1. Root crown shall be exposed after completion.

3.10 PLANT STABILIZATION

A. Install plant stabilization as follows unless otherwise indicated:

PLANT SIZE	STABILIZATION METHOD
6” in Caliper and Greater	Anchor 4 guys to wood deadmen buried at least 36 inches below grade. Provide turnbuckle and compression spring for each guy wire and tighten securely. Allow enough slack to avoid rigid restraint of tree. Provide soft flexible protection of the trunk from the guy wires. Attach flags to each guy wire, 30 inches above finish grade.
3” to 6” in Caliper	Anchor 3 guys to 30” wood stakes. Install guy wires allowing enough slack to avoid rigid restraint of tree. Provide soft flexible protection of the trunk from the guy wires. Attach flags to each guy wire, 30 inches above finish grade.
Less than 12’ tall	Provide two 6’ tall hardwood stakes driven into the ground at the edge of the root ball 2’ deep. Fasten the tree to the stakes with flexible bands capable of holding the plant steady but not binding.

B. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. Refer to planting plan for location of plants to be receiving underground stabilization.
2. Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.11 PLANT PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Do not apply pruning paint to wounds.

3.12 VEGETATED ROOF GROWING MEDIA INSTALLATION

A. Lightweight Intensive Roof Top Media shall be placed carefully to avoid damage or displacement of other materials such as walls, paving, drainage components, filter fabric, and roofing membrane.

B. Lightweight Intensive Roof Top Media shall be placed to within 1 inch greater than final grade or to a depth of no greater than 8 inches and compacted as described in 3.13.C. below. For final grades greater than 8 inches, place growing media at no greater than 6 inches and repeat procedure until growing media has been compacted within 1 inch of final grade.

C. Compaction shall be performed with a 300-400lbs landscape roller. Mechanical compactors, including plate compactors, are not allowed.

D. After compaction remaining growing media shall be placed at 1 inch greater than final grade and thoroughly watered or jetted over entire area. Low settled areas shall be filled with additional growing media and re-wet to achieve uniform prescribed final grade.

3.13 VEGETATED ROOF VEGETATION INSTALLATION

A. Intensive plant materials shall be installed in accordance with plans.

B. Subdrainage pipe below growing media see plans.

3.14 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

B. Chiseled Edging: Construct chiseled edge separating mulch areas from lawn as shown in the drawings.

3.15 PLANTING AREA MULCHING

A. Layout mulch beds carefully with smooth lines and as indicated on the drawings. Mulch backfilled surfaces of planting areas and other areas indicated.

B. Organic Mulch in Planting Areas: Apply over whole surface of mass planting areas or on isolated plantings as follows:

1. Initial Mulch Application to New Planting Areas:

a. 3” minimum depth for trees, shrubs and groundcovers. Do NOT exceed 4 inches depth.

b. 1 ½” minimum depth for groundcovers, perennials, and annual beds. Do NOT exceed 2 inches depth.

2. Mulch Application to Existing Planting Areas:

a. Supplement mulch as needed to restore entire mulch profile to depths noted for initial mulch application to New Planting Areas.

C. Do not place mulch within 3 inches of tree or large shrub trunks.

3.16 SAND MEDIA INSTALLATION

A. Sand media materials shall be installed in accordance with plans.

B. Subdrainage pipe below media see plans.

3.17 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable

plantings. Spray or treat as required to keep trees and shrubs free of weeds, insects and disease.

1. Supplement mulch when entire mulch profile is 50 percent of depth required for initial mulch application to New Planting Areas. Restore entire mulch profile to depth indicated in these specifications.

B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

1. Supplement entire mulch profile to depth indicated in these specifications. Do not over-apply mulch which can negatively affect the health of plants.

C. Include the following required action at 12 months from Final Acceptance as part of warranty review:

1. Remove tree staking systems, above and below grade.
2. Remove tree saucers.
3. Expose root crowns of all trees planted on the job.

3.18 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

C. After installation and before Final Acceptance remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.19 DISPOSAL

A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION

SECTION 33 11 00 - WATER UTILITY DISTRIBUTION SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with City of Raleigh standards and specifications. See Appendix A City of Raleigh Public Utilities Department Handbook (CORPUD) sections on Domestic Water.
   1. Please note the highlighted in the sections provided within this Project Manual are from the published CORPUD and are not indicative of any special requirements of the Project.
   2. All references to pay items, allowances, and Contract language within the CORPUD are not applicable to this project and should be omitted from the bid.

B. Section 31 23 17 Trenching
C. Section 31 23 19 Dewatering
D. Section 31 23 24 Flowable Fill

1.2 SUBMITTALS

A. Product Data: For each type of the following manufactured or supplied products required:
   1. Pipe Materials
   2. Fittings, gaskets, and other appurtenances

PART 2 PRODUCTS

2.1 MATERIALS

A. All materials including but not inclusive of pipe, fittings, gaskets, etc. shall be provided in according to the water material standards provided in the Water Materials section of the CORPUD

PART 3 EXECUTION

3.1 EXAMINATION

A. Installation shall be coordinated with Engineer and City of Raleigh inspectors for schedule inspections prior to being backfilled.

3.2 INSTALLATION

A. Installation per respective CORPUD section.

3.3 FIELD QUALITY CONTROL

A. All Chlorination, Hydrostatic, and Bacteriological preparation and testing shall be performed per the CORPUD Water Construction Standards
B. Engineer shall be notified of testing schedule and results
C. No additional payments will be made for failed tests.

WATER MATERIAL STANDARDS

1. GENERAL MATERIAL REQUIREMENTS Current specifications of the American Society for Testing Materials (ASTM), American Water Works Association (AWWA), Ductile Iron Pipe Research Association (DIPRA), American Association of State Highway and Transportation Officials (AASHTO), and the American National Standards Institute (ANSI) shall apply in all cases where material is covered by an item in these specifications. All material used shall conform fully to these current standards or be removed from the job at the direction of the Public Utilities Director.

Pipe specimens shall be subjected to tests by an independent testing laboratory at such time as the Public Utilities Department may direct or as specified herein. Pipe not meeting these specifications will be ordered removed by the inspector, and such pipe shall be immediately removed from the job site and not transported to any portion of the project being constructed.

Detail or shop drawings of fire hydrants, valves, air release valves, tapping sleeves and tapping saddles must be approved by the Public Utilities Department prior to installation.

These specifications are not to be considered as proprietary in any way. When a particular brand is listed, it is only used as an aid in describing the type of material being requested.

2. MATERIALS – WATER MAIN AND FITTINGS

a. Water Mains

All water mains shall be pressure class or thickness class ductile iron pipe designed in accordance with AWWA Standard C-150. Design shall be done for external and internal pressures separately, using the larger of the two for the next design thickness. An additional allowance shall be made for corrosion and casting tolerances. The thickness design for external and internal pressures shall use the following conditions:

1) 3 feet minimum cover or as shown on the plans;
2) Laying condition - Type 1;
3) A minimum working pressure of 150 psi for pipes 16 inches and smaller in diameter, and for 24 inches and larger pipe, the design working pressure shall be as determined by the Public Utilities Director, and
4) A surge pressure of 300 psi.

All calculations for thickness shall be in accordance with AWWA Standard C-150, and the calculations shall be submitted to the Public Utilities Director for approval prior to shipping any pipe. The minimum thickness shall be pressure class 350 for pipes 6 inches through 12 inches and pressure class 250 for pipes 16 inches and larger in diameter.

The ductile iron pipe shall be manufactured in accordance with all applicable requirements of AWWA Standard C-151. The ductile iron pipe shall be supplied in nominal lengths of 18 or 20 feet.

The ductile iron pipe shall be cement-mortar lined with a sealcoat in accordance with AWWA Standard C-104. Ductile iron pipe shall be externally bituminous coated in accordance with AWWA C-151.

Pipe joints shall be mechanical or "push-on" manufactured in accordance with AWWA Standard C-111.

Each joint of ductile iron pipe shall be hydrostatically tested before the outside coating and inside lining are applied at the point of manufacture to 500 psi. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture or leakage of the pipe wall.

All materials used in the production of the pipe are to be tested in accordance with AWWA Standard C-151 for their adequacy within the design of the pipe, and certified test results are to be provided to the City upon request. All certified tests, hydrostatic and material are to be performed by an independent testing laboratory at the expense of the pipe manufacturer.

Push-on and mechanical joint pipe shall be as manufactured by the American Cast Iron Pipe Company, United States Pipe and Foundry Company, Griffin Pipe Products Company, McWane Cast Iron Pipe Company or approved equal.

Restrained joints shall be TR Flex or HP LOK as manufactured by U.S. Pipe, Lok-Ring or Flex-Ring as manufactured by American Pipe, Super-Lock as manufactured by Clow, Bolt-Lok or Snap-Lok as manufactured by Griffin or approved equal.

b. Fittings

All fittings shall be manufactured in accordance with AWWA C-110 or C-153 for ductile iron compact fittings. The fittings shall be tested and the manufacturer shall provide certified test results when requested by the City. This testing shall include hydrostatic proof testing of the fittings.

All fittings shall be mechanical joint with the exception of certain above ground piping which may require flange fittings. Mechanical joints shall be manufactured in accordance with AWWA Standard C-111.

All fittings shall be cast iron or ductile iron and shall have a minimum working pressure rating of 250 psi and minimum iron strength of 30,000 psi.

All fitting interiors shall be cement-mortar lined with a sealcoat in accordance with AWWA Standard C-104, and the outside shall be bituminous coated.

Restrained mechanical glands may be used where restraint is needed except when welded restraining rings are required. Restrained mechanical glands provide additional restraint, but do not take the place of required concrete blocking.

45^{o} and 90^{o} bends shall be allowed in the water distribution system for all line sizes when required.

c. Gate Valves

Cast iron or ductile iron resilient wedge style vertical or horizontal gate valves and tapping valves shall be used for all main line and hydrant branch valves in sizes from 6 inches through 24 inches. American, Mueller, Kennedy, AVK, Clow, M&H, and Waterous valves in accordance with AWWA C-509-94, C-515, or the appropriate AWWA standard

as applicable, shall be used. All resilient wedge valves shall have internal and external epoxy coating, O-ring seals at the stuffing box and bonnet to body and dual O-rings at the stem seal above the thrust collar.

Tapping valves shall be the same valves as gate valves listed above, subject to the standards, providing that tapping valves shall have the tapping ring.

Gate valves twelve (12) inches in diameter and smaller, shall be mechanical joint or hub-end all-bell. They shall be "O" ring, open-left valves of the non-rising stem type. These valves shall be designed for a minimum of 175 psi working pressure and 300 psi hydrostatic test pressure with a two (2) inch operating nut. Valves shall be cast iron or ductile iron.

Valves sixteen (16) inches in diameter or greater may be the horizontal gate type or butterfly type, as specified on construction plans, or gate valves as specified above.

Gate valves, horizontal gate valves or butterfly valves shall be used for all main line and hydrant branch valves in sizes 16 inches through 24 inches.

d. Valve Boxes

Adjustable valve boxes shall be class 35 gray cast iron and manufactured in accordance with ASTM A48 and be of the dimensions specified in Detail W-17 of these specifications. Lids shall have the word "Water" cast into the lid. See Detail W-18. All castings must be domestically cast and so indicated by the manufacturers name and “USA” cast into all sections of the valve box. All castings must meet or exceed AASHTO H-20 load rating. Total valve box weight shall be a minimum of 85 lbs and have a minimum lid weight of 25 lbs. Mueller Model AJBV 5 adjustables are permissible.

e. Butterfly Valves

Butterfly valves sixteen inches or greater than (16) inches in diameter shall be Class 150B and shall conform to the latest AWWA Standards C-504, as manufactured by Mueller, Kennedy, Pratt, DeZURIK, or Val-Matic for rubber sealed butterfly valves and valve operating assemblies. “O” ring seals shall also be used exclusively with worm gear.

All valve end connections shall be mechanical joint or victaulic, as required by the detail drawings. Valve seats shall be stainless steel, bronze mating or resilient material. Resilient seat shall be mechanically attached to the valve disc, or mechanically retained in the valve body. Resilient seat shall be fully field adjustable by mechanical means. The valve disc shaft shall be stainless steel or either stub or thru-shaft design. Shafts shall be provided with two-way disc thrusters that are fully adjustable from the outside. Valve shaft bearings shall be heavy duty bronze, properly fitted into hubs integrally cast in the body of the valves.

All butterfly valve gear actuators shall be according to AWWA C-504. The valve operator shall be furnished with a two-inch square operating nut, and be so mounted that the valve will open-left (counter-clockwise). The butterfly valve operator shall have AWWA stops, be suitable for submersible service and be sized in accordance with AWWA torque requirements for a full 150B rated valve.

The manufacturer of the butterfly valve shall be fully responsible for the satisfactory performance of the assembled valve and operator unit. The specified operators shall be factory mounted by the valve manufacturer and shipped to the job site as an operating unit. External painting, hydrostatic testing, travel stop adjustments and crating for shipment shall be in complete compliance with the latest AWWA specification for butterfly valves.

All butterfly valves shall be installed in a standard eccentric precast manhole (diameter appropriate with size valve). Standard Detail W-16

f. Fire Hydrants

Fire hydrants shall comply with AWWA C-502-94 as manufactured for the City of Raleigh by Kennedy, Mueller, Clow, American Darling.

City of Raleigh and all merger area fire hydrant nozzles shall have National Standard Threads.

The City of Raleigh may require fire hydrants to resist accidental and deliberate contaminations of the water supply.

All fire hydrants shall have 2-two-and one-half inch nozzles, and 1- 5" Storz connection nozzle. The nozzle shall be an integral part of the fire hydrant and must be furnished by the manufacturer or authorized distributor designated by the manufacturer. Storz connector shall have the following characteristics: brass hydrant nozzle connection; have hard anodized aluminum Storz ramps and lugs (hydrant and cap side); and require a high-torque Storz spanner wrench in order for the cap to be removed.

See Details W-5 through W-6 for hydrant information pertaining to each town.

The hydrant valve opening shall be five and one-quarter inches with no exceptions. Bronze to bronze threads shall be provided between the hydrant seat or seat ring and the seating attaching assembly. All hydrants must include cast or ductile epoxy lined shoe, rubber drain seals and positive, protective valve stop device.

Hydrants shall be open-left type and shall have a six-inch hub-end or mechanical joint elbow. The hydrant barrel shall be of sufficient length to provide a minimum of three and one-half feet of bury and be of the break-away impact type.

Fire Hydrant Colors

City of Raleigh public fire hydrants shall be painted solid red.

Town of Wendell public fire hydrants shall be painted safety yellow with high reflective aluminum silver caps, bonnets, and operating nuts.

Town of Zebulon public fire hydrants shall be painted red with silver bonnets and operating nuts.

Town of Wake Forest and Town of Garner public and private fire hydrants shall be painted safety yellow with silver caps and operating nuts.

Town of Knightdale public fire hydrants shall be painted solid red

Town of Rolesville public fire hydrants shall be shall be painted solid red Operating nuts on hydrants connected to public mains 12" or larger shall be painted black.

Operating nuts on hydrants connected to public mains of any other size shall be painted silver.

g. Air Release Valves

Water Air release valves shall be two-inch Crispin Pressure Air Valves, Model P 20, with a vacuum check unit, or two-inch Val-Matic, Model VM-45, with a vacuum check unit or equal as approved by the Public Utilities Director. These valves shall be suitable for 150 psi working pressure and designed to allow air to escape automatically while the main is in service and under pressure. The valve shall be housed in a City of Raleigh approved eccentric manhole and shall be installed in accordance with Detail W-19 of these specifications. Air release valve locations shall be approved by the Public Utilities Department, or as shown on the plans. The engineer must field stake the air release location.

h. Tapping Sleeves and Tapping Saddles

Tapping sleeves shall be Mueller mechanical joint, Mueller Outlet Seal, American Uniseal, Kennedy Square Seal, or Clow F5205 or F5207. 100% stainless steel sleeves may also be used, as manufactured by Smith-Blair, Romac, Ford, or JCM provided that all metallic parts of the sleeves shall be 100% stainless steel including bolts. Ductile iron flanges may be included on sleeves or saddles. Test assembly seals with water according to AWWA C-223. All sleeves shall have a minimum of 150 psi working pressure. All taps shall be machine drilled--no burned taps will be allowed.

Tapping saddles may be used on mains 16-inches and larger. In 16 and 24 inch saddles as manufactured by Meuller, American, Kennedy and Clow tapping saddles shall be manufactured of ductile iron providing a factor of safety of 2.5 at a working pressure of 250 psi. In main sizes of 30-inch and larger, ductile iron tapping saddles as manufactured by American Pipe Company or US Pipe Company shall be utilized.

Saddles shall be equipped with a standard AWWA C-110-98 flange connection. Sealing gaskets shall be "O" ring type, high quality molded rubber having an approximate seventy durometer hardness, placed into a groove on the curved surface of the tapping saddle. Straps shall be of alloy steel. Saddles may be used for taps one-half the size of the main or less (i.e. 8-inch tapping saddle for use on a 16-inch main).

i. Water Service Connections

Water service pipe for 3/4 - to 2-inch connections shall be type "K" soft copper with no joints or couplings in the right-of-way. On these water services, the fittings shall be flared copper type brass fittings or compression type fittings.

1 ½ inch and 2 inch taps may only be made with use of a double strap bronze saddle.

Corporation cocks for direct ¾" and 1" taps may be used on ductile iron pipe and shall have AWWA Standard tapered threads. Unions shall be three piece copper to copper.

Curb stops used on gang meter assemblies shall be as manufactured by Mueller, Oniseal, Hayes NuSeal, Ford, A.Y. McDonald ball valve. All corporation stops and curb stops shall be bronze ball valves and shall be appropriate material to material corporation and curb stops as manufactured by Mueller, Ford, and A.Y. McDonald and must have a complete ball and installed in a valve box.

Curb stops are required for ¾" through 2" meters and shall be located 1' from the meter box on the street side. Curb stops shall be installed in a curb stop box as manufactured by Ford, A. Y. McDonald, or Trumbull.
Water meter gang assemblies of ¾" and 1" meters may be allowed on 3/4-inch to 2-inch service connections and shall conform to the requirements shown in Detail W-26. A deviation from this standard may be warranted in some circumstances. Calculations will be required to support the deviation.

Service saddles shall be all bronze with double bronze straps and with a neoprene "O" ring gasket attached to the body. The clamp shall have corporation cock threads. These clamps shall be as Mueller H-16100 series, Jones J 979 or approved equal.

For services greater than 2 inches, the water service pipe shall be 4, 6, 8 or 12 inches in diameter and shall be of ductile iron pipe. Cast iron or ductile iron fittings shall be used on these services. All taps will be made by using the appropriate size tapping sleeve and valve. See Detail W-14. On a "dry line", the connection may be made with a "TEE and Valve" as shown in Detail W-15.

Coppersetters or copper meter yokes shall be 5/8 inch and 12 inches in height as manufactured by Ford or approved equal. All coppersetters shall have locking wings on the angle valve and be of the Ford angle check type.

Curb stops on gang meter assemblies shall be as manufactured by Mueller, Oniseal, Hayes Nuseal, Ford, and A.Y. McDonald. All corporation stops and curb stops shall be bronze ball valves and shall be appropriate material to material as manufactured by Mueller, Ford, and A.Y. McDonald.

j. Meters

All water meters shall be provided and installed by the City of Raleigh Public Utilities Department Meters Division.

k. Meter Boxes and Vaults

All meter boxes and vaults shall be constructed of cast iron, precast concrete, concrete block, high-density polyethylene, or cast-in-place concrete as on details W-23 thru W-35. Meter vault access doors shall be aluminum slam lock type as manufactured by Halliday, U.S.F. Fabrication, or approved equal.

Meter boxes and vaults shall not be placed within sidewalks or driveways unless no other alternatives are available and approval is obtained by the Public Utilities Director. Traffic rated lids and vaults shall be installed for all meters 1 ½" and larger.
The meter box must be set to grade. If for some reason, the grade is altered, then the meter box must be adjusted to match the new grade. This includes the addition of topsoil by a landscape contractor or homeowner, flower gardens, etc.

l. Steel Encasement Pipe

Steel pipe for boring installations shall be high strength steel, welded or smooth-wall seamless manufactured in accordance with ASTM A252 and consisting of grade 2 steel with a minimum yield strength of 35,000 psi. The minimum casing pipe wall thickness shall be 0.375" for bored encasement.

No coatings required for buried or bored encasements but must conform to the noted wall thickness in the table below. All encasement pipe must be approved by the appropriate controlling agency (i.e. NCDOT, RR, etc.) prior to ordering the material.

All carrier piping shall be restrained joint ductile iron. One joint of restrained pipe must extend beyond the ends of the encasement pipe. The minimum inside diameter of steel encasements shall be eight inches greater than the inside dimension of the carrier pipe. See the following table for encasement diameter and thickness:

Carrier Pipe Nominal Diameter (inches)	Encasement Minimum Inside Diameter (inches)	Encasement Nominal Wall Thickness (inches)
6	14	0.375
8	16	0.375
10	18	0.375
12	20	0.375
14	24	0.375
16	26	0.500
18	30	0.500
20	32	0.500
24	36	0.625
30	42	0.625
36	48	0.750
42	56	0.875

Both ends of the casing shall be mortared. Metal "spider" pipe alignment devices shall be installed in all casings with a minimum of two "spiders" per pipe joint one fourth of the pipe joint length in from both the bell and spigot ends. See Detail W-40.

m. Irrigation Rain Sensors

Irrigation rain sensors are devices mounted in an open outdoor area at least five feet from any structure and wired to the common wire of all permanent in ground irrigation systems. Rain sensors shall be capable of overriding the irrigation controller when 1/4" of rainfall has occurred to keep the system from watering in the rain. Rain sensors shall also be UL listed and installed per the manufacturer's recommendations.

n. Irrigation Programmable Controllers

Irrigation programmable controllers are devices installed on all permanent in ground irrigation systems that operate the watering cycle of an irrigation system. Controllers shall be programmable by day of the week and UL listed.

WATER CONSTRUCTION STANDARDS (Public and Private Systems)

As part of the requirement to obtain construction approval for water main extensions, the engineer shall affix the appropriate permit sticker to the original drawings. The various permit stickers are included in appendix D.

The requirements contained in this section shall apply to water main installations constructed for the Public Utilities Department or for private developers who may or may not dedicate the water improvements to the City. All necessary construction permits must be obtained before construction may begin in accordance with North Carolina State Law.

Any Contractor performing work within the City of Raleigh or City of Raleigh Merger Areas such as Garner, Knightdale, Wendell, Zebulon, Wake Forest, and Rolesville, shall have on each job site a copy of these specifications.

1. SCOPE OF WORK

a. The contractor shall furnish all materials, equipment, and labor for excavation, installation, backfilling of water mains and related appurtenances as shown on the plans. The Public Works Department and/or Public Utilities Department shall conduct all City inspections on main extension projects.

b. It shall be the contractor's responsibility to notify the Public Utilities and Public Works Departments at least twenty-four hours in advance of beginning any construction work on any project. The contractor must call the Public Utilities Department at 996-4540 and Public Works at 996-6810 and give the location, project name, individual's name, company name, start date and indicate if it involves water extensions.

c. Contractor shall contact the Public Works department at 996-6810 by 4:15 PM each day to notify where and what will be done the following day. For any work conducted in Garner, Knightdale, Wendell, Zebulon, Wake Forest, and Rolesville or outside the City of Raleigh Service Area the contractor shall contact the Public Utilities Department at 996-4540 by 4:15 PM to notify where and what will be done the following day. Any work requiring inspector observation outside of the normal workday, Monday-Friday, 7:30 a.m. to 4:15 p.m. will be charged to the contractor at the current inspector hourly rate.

d. If a developer, engineer or contractor proceeds with the main installation prior to permit issuance the City may require the work to be reinstalled and the developer, engineer or contractor shall be fully liable for all actions and costs, including prosecution by the City or the State for proceeding with installation prior to issuance of appropriate permit(s).

e. "Field changes" are not considered approved by the Public Utilities Department unless revised plans have been submitted to the Public Utilities Department, reviewed and approved. Therefore, the contractor that proceeds with construction prior to this approval, is at his/her own risk.

f. Contractors working (excavation, boring, or other subsurface breach) around or in the vicinity of existing water lines 12 inches in diameter or larger shall be required to physically spot the existing line to be verified by P.U.D. distribution staff or inspection staff. If other existing lines sizes are in question of conflict the contractor shall be directed by P.U.D. staff of the level of subsurface investigation needed to locate the existing line.
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2. GENERAL TESTING REQUIREMENTS

The City may perform and shall require the contractor to perform, such destructive and nondestructive testing, as it deems necessary in order to inspect the materials and workmanship. These tests shall be in accordance with the procedures established by ASTM and AASHTO. The City shall reserve the right to modify the procedures in testing ditch and backfill compaction to allow a deeper test to be made by using the sand-core method and/or nuclear testing gauges.

3. HANDLING AND STORAGE OF MATERIALS

a. The contractor shall be responsible for the shipping and storing of all water materials. The contractor shall replace any material which is damaged or defective.

b. The loading and unloading of all pipe, valves, hydrants, and other accessories shall be in accordance with the manufacturer's recommended practices and shall at all times be performed with care to avoid any damage to the material.

c. The contractor shall locate and provide the necessary storage areas for materials and equipment. If private property is being used for storage areas, then the contractor must have the written consent from the owner. Without this written consent, all material and equipment shall be stored within the existing rights-of-way and easements of the project. Pipe may not be prestrung along job site; it must be delivered to and removed from job site each day. In extenuating circumstances when the inspector authorizes pipe to remain on the project from one day to the next, the ends of the pipe must be sealed.

d. All materials, once on the job site, shall be stored in accordance with the manufacturer's recommendations.

e. All pipes shall be kept free of dirt and other debris. Any damage relating to the coating of the various materials for water mains shall be repaired in a manner approved by the City.

f. The contractor shall be responsible for safeguarding and protecting all material and equipment stored on the job site. The contractor shall be responsible for the storage of materials in a safe and workmanlike manner to prevent injuries, during and after working hours, until the project is complete.

4. BARRICADES, SIGNS AND STREET PROVISIONS

a. Signs, barricades, warning lights, guard rails and flaggers shall be employed as necessary when construction endangers either vehicular or pedestrian traffic. These devices shall remain in place until the traffic may proceed normally again. The contractor shall hold the City harmless for any damages or injuries caused by the construction of water mains.

b. Detours and all traffic control measures shall be set up and maintained by the contractor under the direction of the City of Raleigh Department of Transportation and the North Carolina Department of Transportation. Notice must be given a week in advance of the detour so that necessary notification of the traveling public may be made. The contractor will furnish all barricades, signs, lights and other safety devices to protect his/her construction. The contractor is in no way relieved of liability for providing this protection because others approve the detour.

c. Construction work zone signs and signing procedures shall conform to the MUTCD and supplements and to all applicable federal, state and local codes. The contractor shall be responsible for securing the necessary permits from the City's and the State's Department of Transportation and Inspections for all work to be performed in the public rights-of-way.

5. PROPERTY PROTECTION

Trees, fences, poles and all other property shall be protected unless their removal is authorized, and any property not authorized for removal, but damaged by the contractor, shall be restored by the contractor to the owner's satisfaction.

6. GENERAL CONSTRUCTION SAFETY

a. The contractor and any subcontractors shall be responsible for the total compliance with all federal, state and local ordinances, laws and regulations as related to safe construction practices and to protecting the employees and the public's health and safety.

b. The contractor shall ensure that all Occupational Safety and Health Administration (OSHA) regulations and standards are followed during all phases of the construction project.

c. The City shall not be responsible for the contractor's adherence to OSHA regulations and standards. However, the City may report known violations or unsafe practices to the appropriate enforcement agency.

d. The contractor shall be required to furnish safety equipment necessary to inspect the work including, but not limited to ladders, gas detectors/oxygen sensors, blowers, etc.

7. ENCROACHMENT CONTRACTS AND PERMITS

a. Prior to actual construction, the contractor shall acquire the necessary encroachments from NCDOT when working within the rights-of-way of state system roads or highways. The encroachment permit shall be kept on the job site at all times.

b. The contractor shall be responsible for securing all other local, state and federal permits required for the utility construction.

c. The contractor must have an approved set of permitted construction plans on site at all times.

d. For projects which require construction plan approval, all environmental permits and NCDOT encroachments must be provided prior to plan approval. See general policies and regulations section Page 25.

8. PAVEMENT REMOVAL AND REPLACEMENT

a. All pavements to be removed shall be cut along straight lines with the appropriate saw cut machine. The removal and replacement of the pavement shall conform to the information shown in Details W-1 & W-2.

b. All cuts of City streets must be patched the same day with a temporary or permanent patch. Once work has been completed, all temporary patches shall be replaced with permanent ones. All work from patching shall be cleaned up at the same time of patching.

c. The City of Raleigh shall perform density tests as needed to determine contractor's compactive efforts. See Note 2 and 3 of detail W-2.

d. Pavement cuts shall be confined to a maximum trench bottom width as shown in Details W-1 thru W-3, plus 12 inches on either side.

e. Asphalt compaction shall be done with a gasoline or diesel powered smooth drum asphaltic roller.

f. Pavement cuts within NCDOT Right of Way shall not be performed without the proper encroachment permits on site. All patching of NCDOT pavements shall conform to the approved on site encroachment permit.

9. VALVE OPERATIONS

a. No valve in the existing system shall be operated without following the procedure outlined below. Failure to comply with these requirements shall be grounds for suspension of pipe-laying operations until written assurance can be obtained from a company official that such noncompliance will not occur again. The contractor should be aware that the City regards violations of these requirements as justifying punitive measures.

b. Notification procedures are as follows:

1) The contractor shall notify the Public Utilities Department's Water Distribution Division at 996-2737 in order to request the operation of any valves. At least twenty-four hours notice must be given to the Public Utilities Department, and at least twenty-four hours notice must be given to each customer affected by a water cut-off. The contractor is responsible for notifying the affected customers. All valve operations shall be done by Public Utilities Department personnel or by the City's inspector for a particular project. It is illegal for anyone other than a City of Raleigh employee to operate an existing water main valve, unless accompanied by a City of Raleigh employee.

2) The contractor shall provide the following information when calling the Water Distribution Division for valve operation:

(a) Name of person calling;
(b) Name of company;
(c) Telephone number of company;
(d) Location of valve and map number if available;
(e) Reason for requesting operating and whether to be closed or open;
(f) Time valve to be opened or closed, and
(g) Approximate time water line to be out of service.

c. Each time a contractor needs a valve operated, he/she shall again secure permission, following the steps outlined.

d. System valves shall be defined as any valve, which has main pressure against either gate face. Newly installed tapping valves and control valves to networks not yet accepted for service are considered as system valves and should only be operated under guidance of City of Raleigh Inspectors Valves within a network still under construction are not considered as system valves.

e. All newly installed system valves that connect to the active distribution system shall have a valve box cover painted "red" in color and installed on the corresponding valve box to signify that the valve and main are not in service. The "red" valve box cover shall remain in place until the new main is placed into service, when at such time it shall be replaced with a cover as shown on detail W-18.

10. EXCAVATION

a. Prior to any excavation or construction, the contractor shall locate all existing utilities in the field. If help is needed in locating utilities operated by the Public Utilities Department, the contractor should contact the Operations Division (996-2737).

b. Trench width shall be a minimum of twelve inches plus outside diameter of pipe and a maximum of twenty-four inches plus outside diameter of pipe, unless OSHA requires additional trench width. Trench width shall be measured between the faces of the cut at the top elevation of the pipe bell as shown in Detail W-3.

c. Trench bottom conformation, where no special bedding is required, may be that referred to herein as flat bottom where the trench bottom is excavated slightly above grade and cut down to pipe grade by hand in the fine-grading operation. Where the trench bottom is inadvertently cut below grade, it shall be filled to grade with an approved material and thoroughly compacted to 95% or use #67 stone to bring to grade.

d. The maximum length of open trench shall be no more than three hundred feet, unless approval is obtained from the Public Utilities Director.

e. The contractor shall, at his/her own expense, keep all trenches free from water during the excavation for construction of foundations, masonry, water mains. The water shall be pumped out of the trench or check dams shall be built to keep it out of the ditch in such a manner as not to cause injury to the public health, private property or the work in progress. Erosion control measures shall be utilized during this pumping.

f. In trenches where water is present or dewatering is required, the trench shall be stabilized with #67 stone. When the contractor encounters material during trench excavation, at the opinion of the inspector, or Public Utilities Director, that is unsuitable (i.e. "muck"), this material shall be replaced with material that is considered suitable prior to the pipe laying operations. In this case, construction fabrics may be required to prevent the migration of side support away from the pipe.

g. Safety and convenience of the public necessitate that all work, including excavation, be done in such a manner as to cause minimum traffic interruption, both pedestrian and vehicular. Utilities such as fire hydrants, valves, etc., shall be accessible at all times. Gutters and drains shall be left open and clear at all times, and the contractor shall be responsible for all drainage around his work. Unless specifically waived by the Public Works Department, provisions shall be made to maintain vehicular traffic on all streets in which work is in progress, and suitable walkways shall be maintained for pedestrian travel.

h. Sheeting or bracing shall be used wherever necessary to prevent failure of the trench banks. All sheeting shall conform to AASHTO and OSHA safety standards. The decision of the Public Utilities Director or Engineer relative to bracing for the protection of property of the City shall be binding upon the contractor. The removal of sheeting shall be done in such a manner as to minimize the loss of friction between the backfill and trench walls.

11. ROCK EXCAVATION

a. Rock shall be defined as that solid material that cannot be excavated, in the opinion of the Public Utilities Director or Engineer, by any means other than drilling and blasting, drilling and wedging, or boulders and broken concrete exceeding ½ cubic yard in volume. Rock shall be excavated to the same limits as earth excavation except that the trench shall be made 6- inches lower than the outer bottom of the pipe. This 6-inches shall be refilled with 6-inches of #67 stone and thoroughly compacted to the sub-grade level. All blasting shall be done under the supervision of the City Inspector or Engineer and subject to all applicable regulations. The City reserves the right to require the removal of rock by means other than blasting where any pipe or conduit is either too close to or so situated with respect to the blasting as to make blasting hazardous. Rock taken from the ditch shall immediately be hauled away and disposed of by the contractor.

b. Blasting procedures shall conform to all applicable local, state and federal laws and ordinances. A blasting permit shall be obtained from the City of Raleigh Fire Marshal's Office, prior to any blasting. The application shall be obtained 24-hours before any blasting takes place, and the Fire Marshal may specify the hours of blasting. The contractor shall take all necessary precautions to protect life and property, including the use of an approved blasting mat where there exists the danger of throwing rock or over-burden. The contractor shall keep explosive materials that are on the job site in special constructed boxes provided with locks. Failure to comply with this specification shall be grounds for suspension of blasting operations until full compliance is made. No blasting shall be allowed unless a galvanometer is employed to check cap circuits. Where blasting takes place within five-hundred feet of a utility, structure or property which could be damaged by vibration, concussion or falling rock, the contractor shall be required to take seismograph readings and to keep a blasting log containing the following information for each and every shot.

1) Date of shot
2) Time of shot
3) Crew Supervisor
4) Number and depth of holes
5) Approximate depth of overburden
6) Amount and type of explosive used in each hole
7) Type of caps used (instant or delay)
8) The weather
9) Seismograph instrument and readings

c. This blasting log shall be made available to the Public Utilities Director or Engineer upon request and shall be kept in an orderly manner. It shall be the contractor's responsibility to have adequate insurance to cover any damages resulting from blasting so to hold the City of Raleigh harmless from any claims.

12. TRENCH PREPARATION

a. Trench excavation shall conform to the line and depth shown on the plans. The trench shall be properly braced and drained so that workers may work therein safely and efficiently. When water is being pumped from the trench, the pump discharge shall follow natural drainage channels, drains or storm sewers. In discharging trench water, it will be necessary to follow standard erosion control measures so as to minimize erosion and sedimentation. In no case may trench water or groundwater be pumped into or allowed to enter the sanitary sewer system.

b. The width of the trench may vary with the depth of cut and other conditions the trench shall be in accordance with the dimensions set forth by OSHA and other information shown on Detail W-3.

c. The foundations for ductile iron shall be a firm and stable flat bottom (Type 1) trench with bell holes so that the pipe rests uniformly on the entire barrel length. See Detail W-3.

d. Pipe clearance in rock shall be a minimum of six inches below and on each side of the pipe for sized sixteen inches and less in diameter. For sizes larger than sixteen inches in diameter, the minimum clearance shall be nine inches below and on each side.

13. PIPE INSTALLATION

a. Ductile iron pipe shall be installed in accordance with the requirements of AWWA Standard C-600.

b. Water pipe shall be laid to the line and grade shown on the plans with all valves and hydrants located as shown on the plans.

c. Protection shall be afforded to all underground and surface structures using methods acceptable to the Public Utilities Director or Engineer. This protection shall be furnished by the contractor at the contractors' own expense.

d. Deviation from line and grade may be made only on revised plans upon approval by Public Utilities Department and identified on “as builts” when such deviations arise from grade or line conflicts with existing utilities, structures or other sources of conflict.

e. Subsurface explorations shall be made by the contractor at the direction of the Public Utilities Director or Engineer where it is necessary to determine the location of existing pipes, valves or other underground structures.

f. Depth of pipe cover, unless shown otherwise on the plans shall be three feet above top of pipe. Depth of cover shall be measured from the established street grade or the surface of the permanent improvement to the top of the barrel of the pipe. If minimum cover cannot be maintained due to other agency/development infrastructure projects existing water lines shall be relocated or protected with casings or concrete. In no case shall sub grade construction excavations come within less than 2 feet of the existing pipe crown.

g. After the foundation has been properly graded, bedded when applicable, and the bell holes dug, the pipe and accessories shall be carefully lowered into the trench by approved methods. Under no circumstances shall the pipe or accessories be dropped or dumped into the trench. All damaged pipe and accessories shall be removed from the job.

h. Pipe interior shall be swabbed clean with sodium hypochlorite solution before it is laid, and any pipe which cannot be cleaned with a swab shall be removed and cleaned with suitable apparatus. Any pipe showing evidence of oil, tar or grease shall be permanently marked and removed from the job.

i. Laying of pipe and jointing of pipe shall be done according to manufacturer's recommendation with care being taken to provide uniform bearing for the pipe. Bell and spigot of pipe shall be cleaned and properly lubricated where a mechanical joint of a "push on" type joint is employed. No chlorine powder or tablets shall be put in the lines during installation.

j. Open ends of pipe shall be plugged with a standard plug or cap at all times when pipe laying is not in progress. Trench water shall not be permitted to enter pipe.

k. Pipe cutting for inserting valves, fittings or closure pieces shall be done in a neat and workmanlike manner in accordance with the manufacturer's recommendations and without damage to the pipe.

l. Bell ends will face the direction of laying unless otherwise directed by the Public Utilities Director or Engineer. For lines on an appreciable slope, the Public Utilities Director or Engineer may also require that bell ends face upgrade.

m. Maximum horizontal deflections for ductile iron pipe shall be as follows for an eighteen foot joint of pipe:

Maximum Deflection in Inches		
Pipe Size	Mech. Joint	Push-on-joint
6	27	19
8	20	19
10	20	19
12	20	19
14	13	11
16	13	11
18	11	11
20	11	11
24	9	11
30	9	11
36	8	11
42	7	7
48	7	7

n. When installing water &/or sewer mains, the horizontal separation between utilities shall be 10'. If this separation cannot be maintained due to existing conditions, the variation allowed is the water main in a separate trench with the elevation of the water main at least 18" above the top of the sewer & must be approved by the Public Utilities Director. All distances are measured from outside diameter to outside diameter

Where it is impossible to obtain proper separation, or anytime a sanitary sewer passes over a water main, DIP materials or steel encasement extended 10' on each side of crossing must be specified & installed to waterline specifications

Maintain 18" min. vertical separation at all water main & RCP storm drain crossings; Where adequate separations cannot be achieved, specify DIP materials & a concrete cradle having 6" min. clearance (per CORPUD detail W-41)

All other underground utilities shall cross water & sewer facilities with 18" min. vertical separation required

o. Maintain 18" min. vertical separation at all water main & storm drain crossings. Where adequate separations cannot be achieved, specify DIP materials & a concrete cradle having 6" min. clearance (per COR PUD details W-41.)

p. All other underground utilities shall cross water & sewer facilities with 18" min. vertical separation required

q. Railroad crossings shall be made following all precautionary construction measures required by the railroad officials.

r. All water crossings under the state system roads shall be made in accordance with the requirements of the NC DOT as defined in their encroachment permits.

s. Where conditions are, in the opinion of the City Inspector unsuitable for laying pipe because of weather or trench conditions, the contractor shall be required to cease work until permission is given by the City Inspector for work to commence again providing such conditions have been corrected.

14. REACTION BLOCKING

a. All fittings or components subject to hydrostatic thrust shall be securely anchored by the use of concrete thrust blocks poured in place, unless otherwise directed by the engineer. The reaction areas required for these thrust blocks shall be given to the contractor by the inspector, and the contractor shall install the blocks according to directions provided by the inspector. Where concrete must be reinforced, the contractor shall furnish such reinforcing as is required.

b. Required reaction bearing areas will be taken from the schedule herein. See Details W-10 & W-11. Areas given are vertical plans measured in solid material normal to the thrust line of the fitting.

c. Material for reaction blocking shall be transit-mixed concrete. This concrete shall have a twenty-eight day compressive strength of 3000 psi. Any metal used to resist thrust which is not encased in concrete shall be "hot dipped" galvanized.

d. Valves on ductile iron lines shall be anchored with thrust collars as shown in Details W-7 thru W-9.

15. BACKFILLING PIPE

a. The backfilling of the trench after the pipe installation and testing shall be in accordance with Details W-3 for ductile iron.

Ductile iron pipe shall be backfilled with suitable native material. No rocks, boulders or stone four inches or larger shall be included in the backfill for at least two feet above the top of the pipe.

b. All backfill shall be compacted in six-inch lifts measured from the pipe foundation upward. Backfill for roadway shall be compacted to at least 95% of maximum soil density in those areas where the supporting capacity of the soil is of prime consideration. Laboratory determination of maximum soil density will follow the procedure of AASHTO T99-86. Field determination of the density of the soil in place shall follow the procedure of AASHTO T191-86 or T204-86. The result of any one test may be a minimum of 90% of maximum density, but the average of any three tests in an area shall be 95% of maximum density. All tests shall be conducted at the direction of the City Inspector, and the cost of such tests will be borne by the contractor with the provision that the City will test an area two times only where both tests fail. The contractor shall then be required to submit satisfactory evidence that his ditch compaction meets the specifications.

c. Deficiency of backfill material shall be supplied by the contractor where this deficiency results from any cause other than rejection of unsuitable backfill material (other than rock) by the City Inspector. In cases where the City Inspector directs, the contractor shall dispose of unsuitable backfill material and provide suitable backfill material.

Where excavated material has been rendered unsuitable, either before or after excavation, by inclement weather or type of material, the contractor must correct the moisture or furnish replacement backfill material.

d. Backfilling shall not be allowed, except with permission of the City Inspector. When a ditch is flooded or the weather is unsuitable, the contractor shall not backfill unless permission is given by the City Inspector. No backfilling with frozen material shall be allowed.

16. SETTING VALVES AND VALVE BOXES

a. Valves shall be set at locations shown on the plans with care being taken to support the valve properly and to accurately position the valve box over the operating nut of the valve. Where pavement exists, the box shall be adjusted to finished street grade and a concrete pad two-feet square and six inches thick shall be poured around the box two inches from the top of finished grade as shown in Detail W-17. When valves are located in street rights-of-way, but out of pavement, the boxes shall be adjusted to finished grade and a concrete pad two-feet square and six-inches thick shall be poured around the box one-half inch from the top. When valves are located outside of street rights-of-way, the boxes shall be at finish grade, and a concrete block two-feet square and six-inches thick shall be poured around the box at grade line. Valve locations out of street rights-of-way shall be marked with a metal post having a minimum diameter of two inches and a minimum bury of three feet with a minimum of three feet exposed. The exposed portion shall be painted bright orange and shall be placed so that a valve operating tool has free operation.

b. When a tapping sleeve and valve are being used, the valve, sleeve and machine assembly shall be air tested to hold at 150 psi for a five-minute duration in the presence of the inspector prior to drilling or tapping the main. All tap coupons shall be given to the city inspector. The valve shall be in the closed position during the testing.

c. Reverse taps are not permitted unless approved by the Public Utilities Director. They must have sufficient cover and be marked with a 4 inch PVC marker at the tapping valve identified with an "R" designation.

17. SETTING FITTINGS

Fittings shall be set at locations shown on the plans with care being taken to properly "bell-up" joints and support the body of the fitting. All dead-end lines shall be plugged with mechanical joint plugs or caps and anchored by using thrust collars and blocking as shown on Details W-7 thru W-12.

18. SETTING HYDRANTS

a. Specific directions are required for the setting of all hydrants. In streets where paving is proposed in the near future, the contractor will be given line and grade stakes for hydrants. It is mandatory for the contractor to preserve these stakes for the inspector to verify that the hydrant was set correctly. In areas where paving is not anticipated in the near future, hydrants shall be set according to the inspector's directions. When fire hydrants are installed behind guard rails breakaway flanges shall be installed at the ground level and flush with the top of the guard rail. In these installations where multiple barrel extensions are required the fire hydrant stems shall be a single one piece unit. In general, hydrants shall be located in a manner to provide complete accessibility and minimize possibility of damage from vehicles or injury to pedestrians.

b. Hydrant installation shall be as shown in Detail W-4 and shall be restrained from the main to the hydrant with a mechanical joint pipe restraining system. If the distance is greater than 20 feet the hydrant branch shall be restrained for the entire length with a mechanical joint pipe restraining system. When hydrants are used as blow-off assemblies, the valves shall be rodded to a thrust block. Restraining rods and accessories shall be "hot dipped" galvanized. Detail W-4A is another available option.

c. Before a hydrant is set, all dirt and foreign matter shall be removed from the interior of the hydrant.

d. Hydrants shall be bagged to indicate "out of service" until all testing is complete and the mains are placed in service. Bags shall be large enough to cover the entire hydrant and shall be black in color. Bags shall be secured with duct tape at the base of the hydrant and shall be removed immediately after the hydrants are placed in service.

19. SETTING BLOW-OFFS AND RELEASE VALVES

a. Blow-offs and drainage branches shall not be connected to any sewer, submerged in any stream, or be installed in any other manner that will permit back siphonage into the distribution system.

b. All air release valves and blow-offs shall be installed as shown on Details W-19 - W-22. Air release valves must be such that provisions can be made by the contractor to get the flow of water to a natural drainage way.

20. SURFACE RESTORATION

a. All disturbed surfaces and property thereon, shall be restored to a condition equal to that existing before construction began, and the contractor shall maintain and be responsible for all ditches in paved streets, curbs, gutters or sidewalks until the contractor repaves the trench cuts. The contractor, with permission of the inspector, may place temporary or permanent asphaltic material in the cut. Asphalt compaction shall be done with a gasoline or diesel powered smooth drum asphaltic roller.

b. All easements will be seeded with grass and left so they can be mowed by conventional mowers, unless approved by the Public Utilities Department for rip-rap or other specified material. In remote areas, easements will be seeded with a quality fescue grass. In residential areas, easements will be seeded with either falcon or rebel fescue or leaf mulch at the request of property owner. The contractor shall guarantee a good uniform stand of grass and shall reseed any bare or thin spots. The contractor will be responsible for a one-year warranty on materials and workmanship.

21. EROSION CONTROL

Erosion control measures shall be performed by the contractor, conforming to the requirements of, and in accordance with plans approved by the State of North Carolina Department of Environment and Natural Resources, North Carolina Sedimentation Control Commission and City of Raleigh Inspections Department Erosion Control Division, and as per the erosion control plan portion of the construction drawings and these specifications. The sedimentation and erosion control plan and permit shall remain on site at all times. The contractor shall not allow mud and debris to accumulate in the streets. Should the contractor pump water from trenches during construction, appropriate siltation preventative measures shall be taken prior to the entry into any storm drain or stream. All measures must be taken so that stormwater runoff does not go to the pipes or manholes of the utility system. All materials used for erosion control shall be approved by the Engineer prior to installation by the contractor.

a. Temporary and permanent erosion control measures shall be shown on the plans. Temporary and permanent erosion control work shall be coordinated throughout the project to provide effective and continuous erosion control throughout construction and post construction, which minimizes siltation of streams, lakes, reservoirs, other water impoundments, ground surface, or other property. Seeding and mulching shall be carried out immediately behind construction.

b. Temporary erosion control measures shall include but not be limited to swales in the easements, silt fences, crushed stone check dam devices, silt basins (sedimentation traps), mulching, earth berms, and rip-rap.

c. Permanent erosion control measures shall include but not be limited to swales in the easements, rip rap and seeding of disturbed areas.

d. Erosion and siltation shall be controlled on projects by using swales to control run-off and convey run-off to controlled discharge points, by silt fences, rip-rap, crushed stone, and earth berms to contain silt, with pipe culverts where major access or haul roads cross drainage ditches or streams, silt basins where pipe lines cross drainage ditches or streams, and seeding and mulching will be performed as soon after pipe installation as possible. When temporary measures are removed after completion of the project the disturbed area must be stabilized, if necessary.

22. MAINTAINING SERVICE

When replacing or extending water mains the contractor shall maintain continuous water service to all existing residences and businesses.

23. GUARANTEE

The contractor shall guarantee all material, equipment and workmanship for a period of at least one-year after final acceptance by the City. The Public Works Department Construction Inspection Division is responsible for the issuance of final acceptance letters by the City.

For projects in Merger Areas the Public Utilities Department Construction Inspection Division is responsible for issuance of final acceptance letters.

24. WETLAND/STREAM BUFFERS

Conditions of 401/404 permits shall be strictly followed to the satisfaction of Corps of Engineers. All Neuse Riparian buffers shall be maintained as required by the North Carolina Division of Water Quality.

25. GENERAL WATER MAIN TESTING SEQUENCE

Water mains shall be tested in the following general sequence:

a) "Pigging" main (mains with gate valves)

b) Flush the main (all flush water shall be de-chlorinated using methods acceptable to the City of Raleigh Public Utilities Department);

c) Perform the hydrostatic tests;

d) Introduce the appropriate amount of chlorine by tapping the main;

e) Hold the chlorine solution in the main for at least twenty-four hours and no more than seventy-two hours;

f) Flush the main (all flush water shall be de-chlorinated using methods acceptable to the City of Raleigh Public Utilities Department);

g) Sample for the bacteriological tests; and

h) Water mains shall be placed into service within 48 hours of meeting bacteriological analysis requirements. If no activity is anticipated on a water main for the first 30 days after it is placed into service, the contractor shall notify the City of Raleigh Public Utilities Department at 870-2870 and provide the location and permit number.

26. PIGGING

All new mains with gate valves must be pigged with a polyethylene "pig", 5#/cubic foot density at the conclusion of installation.

The pig must be blown at the end of the main by means of the following:

a) 4" main - 4" blow-off (private only)
b) 6" main - fire hydrant or 6" blow-off
c) 8" and 12" through blow-off assembly as on Details W-21 & W-22
d) 16" – 24" As determined by the field inspector

The contractor installing the line shall write the name of the company and street name in which the work is taking place on the pig in a manner in which it will not rub off.

27. HYDROSTATIC TESTS

a. All main installations including private distribution and fire lines to the buildings shall be pressure tested between each main line valve in accordance with AWWA C-600. The test shall be performed using a suitable pump and an accurate pressure gauge. Immediately upon completion of a section of main, 150 psi (± 5 psi) of pressure shall be applied and held for two hours. Fire lines shall be tested at 200 psi. The acceptable leakage rate shall not exceed .092 gallons per inch of pipe diameter per 1,000 feet of pipe per hour.

Failure of the water main to comply with the above acceptable leakage rate, shall require the contractor to replace any defective materials to insure a watertight installation. If it is deemed that the existing blow-off valve is the cause of failure, the party responsible for the water main extension shall also be responsible for adding a valve at that location and abandoning the existing valve. After any inadequacies have been corrected, the leakage rate will again be tested. This test shall be repeated until that portion of main is brought to compliance with the permissible leakage rate.

b. Prerequisite conditions for inspection prior to testing shall be as follows:

1) Hydrants shall be properly located, operable, plumb and at correct elevation.

2) Valves shall be properly located, operable and at correct elevation. Valve boxes or manholes shall be centered over operating nuts, and the top of the box or manhole shall be at proper elevation.

3) Lines shall be properly vented where entrapped air is a consideration.

28. CHLORINATION

a. All additions or replacements to the water system, including fire lines and backflow prevention devices, shall be chlorinated before being placed in service. Such chlorination must take place under the supervision of an inspector.

b. Pipe subjected to contaminating materials shall be treated as directed by the Public Utilities Department or Engineer. Should such treatment fail to cleanse the pipe, replacement shall be required. The City shall bear no portion of any cost sustained by the contractor in meeting this specification.

c. Chlorination of a completed line shall be carried out after completing the pressure test and in the following manner.

1) Taps will be made at the control valve at the upstream end of the line and at all extremities of the line including valves. These taps shall be located in such a manner as to allow HTH solution to be fed into all parts of the line.

2) A solution of water containing high test hypochlorite (70%) available chlorine or chlorine gas solution shall be introduced into the line by regulated pumping at the control valve tap. The solution shall be of such a concentration that the line shall have a uniform concentration of 50 ppm total chlorine immediately after chlorination. The chart below shows the required quantity of 70% HTH compound to be contained in solution in each 1000-foot section of line to produce the desired concentration of 50 ppm.

Pipe Size	Pounds of high Test Hypochlorite (70%) Per 1000' of Line
6"	.88
8"	1.56
10"	2.42
12"	3.50
14"	4.76
16"	6.22
20"	9.76
24"	14.00
30"	21.00
36"	31.50
48"	56.00

3) The HTH solution shall be circulated in the main by opening the control valve and systematically manipulating hydrants and taps at the line extremities. The HTH solution must be pumped in at a constant rate for each discharge rate in order that a uniform concentration will be produced in the mains.

4) Services shall be sterilized by methods acceptable to the Public Utilities Director or Engineer, and the contractor shall have the same responsibility for laterals as for mains in regard to bearing full cost of any corrective measures needed to comply with bacteriological or other requirements.

5) HTH solution shall remain in lines for no less than twenty-four hours, unless otherwise directed by the Public Utilities Director or Engineer.

5) Extreme care will be exercised at all times to prevent the HTH solution from entering existing mains.

29. BACTERIOLOGICAL SAMPLING

a. Free residual chlorine after twenty-four hours shall be at least 10 ppm, or the Public Utilities Department or Engineer will require the lines be re-chlorinated.

b. Mains will be flushed with a blow-off assembly of sufficient size to effectively clean the main. Detail W-22. Flushing of lines may proceed after twenty-four hours, provided the free residual chlorine analysis is satisfactory. Flushing shall be continued until chlorine returns to normal level. In times of water shortages or distribution main problems, the flushing operation may be delayed. The Public Utilities Department shall determine when flushing is allowable. The contractor shall advise the inspector prior to the chlorination and flushing so that the inspector can advise the Public Utilities Department of the construction location, size and length of mains. All tests will be done in the presence of an inspector. Flushing will be for short duration. Sufficient precautions must be taken to the satisfaction of the inspector to ensure that the impact of the water is absorbed and the water is conveyed without erosion or property drainage. All flush water shall be de-chlorinated using methods acceptable to the City of Raleigh Public Utilities Department.

c. After flushing is completed, the Public Works Department or Public Utilities Department Inspector shall collect samples for turbidity and bacteriological analysis for each section of pipe between main line valves. Sample point locations shall be determined by a representative of the engineer or owner.
A custody seal shall be placed on each set of turbidity and bacteriological bottles. A chain of custody form must be completed for sample set(s) collected and must be delivered along with the sample(s). A turbidity test will be done. If the turbidity exceeds 1 NTU, the sample fails and a bacteriological test will not be set up. The Public Utilities Department will perform the turbidity and bacteriological analysis.

d. Samples will be accepted between 8:00 AM and 12 NOON and 1PM and 3:30 PM Monday through Thursday, excluding holidays. Special arrangements may be made for samples to be accepted outside of this time frame by calling the laboratory in advance.

e. In the event that two successive bacteriologic tests fail, that section of the main shall be re-chlorinated by the contractor and new tests performed prior to moving to the next section of main.

30. SERVICE CONNECTIONS

a. Taps shall be made only on a line under pressure and after the main has been tested and chlorinated. No taps on dry lines shall be allowed, unless specific authorization from the Public Utilities Department is obtained.

b. Taps shall be at an angle of forty-five degrees to a perpendicular plane through the center line of the pipe as shown is in Detail W-23.

c. The maximum size of a direct tap shall be 1” for mains 6” and larger. Larger taps may be made by using a service saddle.

d. Services larger than two inches shall be made by using a tapping sleeve and valve. Service size shall match tap size.

The typical tapping sleeve and valve is shown in Standard Detail W-14.

SECTION 33 30 00 – SANITARY SEWER UTILITY DISTRIBUTION SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with City of Raleigh standards and specifications. See Appendix B City of Raleigh Public Utilities Department Handbook (CORPUD) sections on Sanitary Sewer.
   1. Please note the highlighted in the sections provided within this Project Manual are from the published CORPUD and are not indicative of any special requirements of the Project.
   2. All references to pay items, allowances, and Contract language within the CORPUD are not applicable to this project and should be omitted from the bid.

B. Section 31 23 17 Trenching
C. Section 31 23 19 Dewatering
D. Section 31 23 24 Flowable Fill

1.2 SUBMITTALS

A. Product Data: For each type of the following manufactured or supplied products required:
   1. Pipe Materials
   2. Fittings, gaskets, and other appurtenances
   3. Manholes
   4. Cleanout lids
   5. Ring and covers

PART 2 PRODUCTS

2.1 MATERIALS

A. All materials including but not inclusive of pipe, fittings, gaskets, etc. shall be provided in according to the sewer material standards provided in the Sewer Materials section of the CORPUD

PART 3 EXECUTION

3.1 EXAMINATION

A. Installation shall be coordinated with Engineer and City of Raleigh inspectors for schedule inspections prior to being backfilled.

3.2 INSTALLATION

A. Installation per respective CORPUD section.

3.3 FIELD QUALITY CONTROL

A. All testing shall be performed per the CORPUD Construction Specifications for Sewer Mains
B. Engineer shall be notified of testing schedule and results
C. No additional payments will be made for failed tests.

SEWER MATERIAL STANDARDS

I. GENERAL MATERIAL

Current specifications of the American Society for Testing Materials (ASTM), American Water Works Association (AWWA), the American National Standards Institute (ANSI), the American Association of State Highway and Transportation Officials (AASHTO), and Ductile Iron Pipe Research Association (DIPRA) shall apply in all cases where material is covered by an item in these specifications. All material used shall conform fully to these current standards or be removed from the job at the direction of the Public Utilities Director.

Pipe specimens shall be subjected to tests by an independent testing laboratory at such time as the Public Utilities Department may direct or as specified herein. Pipe not meeting these specifications will be ordered removed by the inspector, and such pipe shall be immediately removed from the job site and not transported to any portion of the project being constructed.

These specifications are not to be considered as proprietary in any way. When a particular brand is listed, it is only used as an aid in describing the type of material being requested.

2. PIPE MATERIALS (Gravity Mains Only)

a. Centrifugally Cast Fiberglass Reinforced Polymer Mortar (CCFRPM) Pipe

Centrifugally Cast Fiberglass Reinforced Polymer Mortar (CCFRPM) Pipe shall conform to ASTM D3262 for CCFRPM pipe manufactured of "Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) materials and to the following requirements.

1. CCFRPM pipe shall be as manufactured by HOBAS Pipe USA or approved equal.
2. CCFRPM pipe shall only be allowed for 18" diameter and larger pipe.
3. Pipe shall be suitable for laying condition as shown in standard detail S-1 at the depth indicated on the Drawings. Pipe manufacturer to verify pipe selection and document to the Engineer prior to ordering and manufacture of pipe.
4. Pipe shall conform to ASTM D2412 for minimum stiffness and external loading characteristics.
5. Couplings, fittings, and push-on joints shall be manufactured with flexible elastomeric seals conforming to the requirements of ASTM D4161 and ASTM F477 and shall meet or exceed the pipe class at the location of its installation.
6. Pipe joint shall be push-on type couplings unless specified otherwise.
7. Pipe shall meet the minimum requirements of ASTM D3681 and ASTM D3262. Manufacturer shall provide complete 10,000-hour test results on pipe produced at the proposed location of manufacture. Results shall reflect that the pipe has a minimum allowable strain of no less than .9% at fifty years when tested in accordance with ASTM D3681 and ATM 3262
8. Normal production pipe for this project shall not incorporate raw materials that are not in compliance with ASTM D3681 and ASTM D3262
9. Interior of the pipe shall be manufactured using a non structural resin with a minimum allowable elongation of 50% when measured in accordance with ASTM D638. The liner nominal thickness shall be 40-mils.
10. Exterior pipe surfaces shall be comprised of a layer of sand and resin to provide UV protection to the exterior.

11. For pipe installed in steel encasement pipe joint shall be flush type and capable of meeting the above requirements.

b. Ductile Iron Pipe and Fittings

Ductile iron pipe and fittings used for sanitary sewers shall be manufactured in accordance with AWWA Standards C-150 and C-110 respectively. The minimum pressure class pipe shall be class 250 or a greater class may be required based upon the depth of cover and laying conditions. Pipe shall be supplied in 18 or 20 foot nominal lengths. Pipe and fittings shall have a minimum working pressure of 250 psi, and minimum iron strength of 30,000 psi. Ductile iron may be used for any sewer main 8-inch and larger. Pipe joints shall be the "Push-on" type manufactured in accordance with AWWA Standard C-111-95.

Interior Linings for Ductile Iron Force Mains and Sewer Interceptors

All force mains, fittings, and gravity interceptors 12-inches and larger shall be lined with an amine cured novalac ceramic epoxy containing at least 20% by volume of ceramic quartz pigment. The lining material shall have a permeability rating of zero when tested in accordance with Method A – ASTM E96-66, Procedure A with test duration of 30 days. The lining shall be applied by a competent firm with a successful history of applying linings to the interior of ductile iron pipe and fittings. Within 8 hours of surface preparation, the interior of the pipe shall receive 40 mils nominal DFT. No lining shall take place when the substrate or ambient temperature is below 40^{o} F. The surface shall also be dry and dust free. The lining shall not be used on the faces of the flanges (if applicable).

Due to the tolerances involved, the gasket area and spigot end up to 6-inches back from the end of the spigot end must be coated with 6 mils nominal, 10 mils maximum of PROTECTO Joint Compound or approved equal. The Joint Compound shall be applied by brush to ensure coverage. Care should be taken that the Joint Compound is smooth without excess buildup in the gasket seat or on the spigot ends. Coating of the gasket seat and spigot ends shall be done after the application of the lining.

The number of coats of lining material applied and the touch up and repair of the lining shall be as recommended by the manufacturer. The pipe manufacturer shall provide a certification attesting that the application meets or exceeds the requirements of these specifications.

Lining material shall be PROTECTO 401, or approved equal.

c. PVC Gravity Sanitary Sewer Pipe

PVC gravity sanitary sewer pipe and related fittings shall be manufactured in accordance with all the requirements of ASTM D-3034-98 SDR 35 Type PSM polyvinyl chloride sewer pipe and fitting. PVC gravity sewer pipe may be used for 8, 10, 12 or 15 inch mains and shall be supplied in 12.5 foot lengths with bell-and-spigot joints. ASTM F679-95 shall establish the requirements for 18, 21, 24 and 27-inch diameter PVC, SDR 35 gravity sewer pipe. The length of joints shall be at least 11 feet for the larger PVC pipe, unless approved differently by the Public Utilities Director. All fittings shall use rubber gaskets, which conform to the requirements of ASTM F477-99.

3. PIPE MATERIALS (Force Mains)

a. Ductile Iron Pipe and Fittings

All Ductile Iron sewer force mains shall be pressure class or thickness class ductile iron pipe designed in accordance with AWWA Standard C-150. Design shall be done for external and internal pressures separately, using the larger of the two for the next design thickness. An additional allowance shall be made for corrosion and casting tolerances. The thickness design for external and internal pressures shall use the following conditions:

1) 3 feet minimum cover or as shown on the plans;
2) Laying condition - Type 1;
3) A minimum working pressure of 150 psi for pipes 16 inches and smaller in diameter, and for 24 inches and larger pipe, the design working pressure shall be as determined by the Public Utilities Director, and
4) A surge pressure of 300 psi.

All calculations for thickness shall be in accordance with AWWA Standard C-150, and the calculations shall be submitted to the Public Utilities Director for approval prior to shipping any pipe. The minimum thickness shall be pressure class 350 for pipes 6 inches through 12 inches and pressure class 250 for pipes 16 inches and larger in diameter.

The ductile iron pipe shall be manufactured in accordance with all applicable requirements of AWWA Standard C-151. The ductile iron pipe shall be supplied in nominal lengths of 18 or 20 feet.

Ductile iron pipe shall be externally bituminous coated in accordance with AWWA C-151.

Pipe joints shall be mechanical or "push-on" manufactured in accordance with AWWA Standard C-111.

Each joint of ductile iron pipe shall be hydrostatically tested before the outside coating and inside lining are applied at the point of manufacture to 500 psi. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture or leakage of the pipe wall.

All materials used in the production of the pipe are to be tested in accordance with AWWA Standard C-151 for their adequacy within the design of the pipe, and certified test results are to be provided to the City upon request. All certified tests, hydrostatic and material are to be performed by an independent testing laboratory at the expense of the pipe manufacturer.

Push-on and mechanical joint pipe shall be as manufactured by the American Cast Iron Pipe Company, United States Pipe and Foundry Company, Griffin Pipe Products Company, McWane Cast Iron Pipe Company or approved equal.

Restrained joints shall be TR Flex or HP LOK as manufactured by U.S. Pipe, Lok-Ring or Flex-Ring as manufactured by American Pipe, Super-Lock as manufactured by Clow, Bolt-Lok or Snap-Lok as manufactured by Griffin or approved equal.

Interior Linings for Ductile Iron Force Mains

All force mains and fittings shall be lined with an amine cured novalac ceramic epoxy containing at least 20% by volume of ceramic quartz pigment. The lining material shall have a permeability rating of zero when tested in accordance with Method A – ASTM E96-66, Procedure A with test duration of 30 days. The lining shall be applied by a competent firm with a successful history of applying linings to the interior of ductile iron pipe and fittings. Within 8 hours of surface preparation, the interior of the pipe shall receive 40 mils nominal DFT. No lining shall take place when the substrate or ambient temperature is below 40° F. The surface shall also be dry and dust free. The lining shall not be used on the faces of the flanges (if applicable).

Due to the tolerances involved, the gasket area and spigot end up to 6-inches back from the end of the spigot end must be coated with 6 mils nominal, 10 mils maximum of PROTECTO Joint Compound or approved equal. The Joint Compound shall be applied by brush to ensure coverage. Care should be taken that the Joint Compound is smooth without excess buildup in the gasket seat or on the spigot ends. Coating of the gasket seat and spigot ends shall be done after the application of the lining.

The number of coats of lining material applied and the touch up and repair of the lining shall be as recommended by the manufacturer. The pipe manufacturer shall provide a certification attesting that the application meets or exceeds the requirements of these specifications.

Lining material shall be PROTECTO 401, or approved equal.

b. Polyvinyl Chloride (PVC) Force Main Pipe and Fittings

Pipe and fitting size, pressure class and DR shall be as indicated on the drawings.

PVC Materials shall comply with ASTM D1784 with a cell classification of 12454-B.

PVC force mains 4”-12” shall conform to AWWA C900 and the following requirements:

1. outside diameter shall conform to Ductile Iron pipe.
2. Pipe shall be a minimum of pressure class 200 with a minimum standard dimension ration of DR14.
3. Pipe shall have plain end and elastomeric-gasket bell ends.
4. Fittings shall conform to AWWA C100 or C153 and have mechanical joints. Fittings shall be made of gray-iron or ductile iron. Interior of fittings shall be lined with Protecto 401 as specified above.

PVC force mains 14”-24” shall conform to AWWA C905 and the following requirements:

1. Outside diameter shall conform to Ductile Iron pipe.
2. Pipe shall be a minimum of pressure class 200 with a minimum standard dimension ration of DR14.
3. Pipe shall have plain end and elastomeric-gasket bell ends.
4. Fittings shall conform to AWWA C100 or C153 and have mechanical joints. Fittings shall be made of gray-iron or ductile iron. Interior of fittings shall be lined with Protecto 401 as specified above.

4. STEEL PIPE (AERIAL and BORED)

Steel pipe for aerial creek crossings shall be high strength steel, helical or straight seam welded manufactured in accordance with ASTM A 139 and consisting of grade "B" steel with a minimum yield strength of 35,000 psi. Thickness, diameter, and allowable spans shall be according to Detail S-12.

Boring installations shall be high strength steel, spiral welded or smooth-wall seamless manufactured in accordance with ASTM A252 and consisting of grade 2 steel with a minimum yield strength of 35,000 psi. The minimum inside diameter of steel encasements shall be eight inches greater than the inside dimension of the carrier pipe. The minimum casing pipe wall thickness shall be 0.375" for bored encasement and in accordance with the table provided below. Thicker encasement pipe may be required by the North Carolina Department of Transportation, railroads, or other agencies.

Carrier Pipe Nominal Diameter (inches)	Encasement Minimum Inside Diameter (inches)	Encasement Nominal Wall Thickness (inches)
6	14	0.375
8	16	0.375
10	18	0.375
12	20	0.375
14	24	0.375
16	26	0.500
18	30	0.500
20	32	0.500
24	36	0.625
30	42	0.625
36	48	0.750
42	56	0.875

The outside of steel pipe for aerial crossings shall be coated with 1 coat of a compatible acrylic polyurethane with a total dry film thickness of 2 – 5 mils per coat. The Acrylic Polyurethane coating shall be Tnemec Endura Shield Series 73, or approved equal. Primer shall be applied as recommended by the manufacturer.

No coatings required for buried or bored encasements but must conform to the noted wall thickness in the table above. All encasement pipe must be approved by the appropriate controlling agency (i.e. NCDOT, RR, etc.) prior to ordering the material.

All carrier piping shall be restrained joint ductile iron TR Flex as manufactured by U.S. Pipe, Lok-Ring or Flex-Ring as manufactured by American Pipe, Super-Lock as manufactured by Clow, Bolt-Lok or Snap-Lok as manufactured by Griffin or approved equal. One joint of restrained pipe must extend beyond the ends of the encasement pipe for boring installations. The restrained joint pipe shall be from manhole to manhole in aerial installations. The minimum inside diameter casing pipe shall be eight inches greater than the inside dimension of the carrier pipe.

Both ends of the casing shall be mortared. Metal "spider" pipe alignment devices shall be installed in all casings with a minimum of two spiders per pipe joint one fourth of the pipe joint length in from both the bell and spigot ends. See Detail S-39.

5. CURED IN PLACE PIPE LINING (CIPP)

CIPP lining may be allowed in lieu of replacing the existing downstream sewer main with Protecto 401 lined DIP or PVC pipe when a new forcemain discharges to an existing sanitary sewer main,

When allowed, the CIPP must adhere to the following specifications.

References:

The latest revision of the publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1. American Society of Testing Materials (ASTM)
   a. D790 Test Method for Flexural Properties of Unreinforced Plastics and Electrical Insulation Materials
   b. D2412 Test Method for determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   c. F1216 Practice for Rehabilitation of Existing Pipe Lines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.

Fabricate a flexible tube to a size that when installed will neatly fit the internal circumference of the conduit specified. Allowance shall be made for circumferential stretching during insertion.

The minimum length shall be that deemed necessary by the contractor to effectively span the distance from the inlet to the outlet of the respective manholes. The contractor shall verify the lengths in the field before impregnation. Individual inversion runs can be made over one or more manhole sections as determined in the field by the contractor and approved by the Engineer.

Furnish a general purpose, unsaturated, polyester resin and catalyst system compatible with the reconstruction inversion process that provides the cured physical strengths specified. CIPP lining shall be Insituform by Insituform Technologies, INC., Inliner by Inliner USA, Inc., KM-Inliner by Spiniello Limited, Inc. or Cure-Line by pipelining Products, Inc. or approved equal.

Physical Strength:

U.S. Licensor Standard	Results
Flexural Stress	#101 (Modified ASTM D-790) 4,500 psi
Flexural Modulus of Elasticity	#101 (Modified ASTM D-790) 250,000psi

Design Thickness:

The liner shall be designed in accordance with the applicable provision of the referenced ASTM standards as structural pipe linings for "fully deteriorated gravity pipe conditions" and shall meet the following design conditions:

1. AASHTO H-20 Live Load with two trucks passing for FFP in streets.
2. Soil weight 120 pounds per cubic foot. Coefficient of friction K'=.130r for the installed depths.
3. Estimated maximum groundwater levels at the height of the manholes.
4. Service temperature range shall be 40-150 degrees F.

6. MANHOLES AND RELATED MATERIALS

Manholes will be precast reinforced concrete. Eccentric or concentric cones may be used on 8 through 12-inch mains. Concentric cones will be used on all 15 inch and larger mains. These different type manholes shall conform to these specifications and the City of Raleigh Standard Details. All manholes located outside public right-of-way must be three feet above the 100-year flood or be sealed as per Details S-24 & S-27. "Candy cane" vent stacks on sewer manholes must be "factory" fabricated and "hot dipped" galvanized, NOT field fabricated and galvanized. All manholes with vent stacks shall be water tight per Detail S-24. All Cam Lock manhole covers outside the 100-year flood plain must be vented with one 1-inch hole in the cover and as per Detail S-27. All manhole covers installed within streets, parking lots, and other paved areas shall have only one 1-inch hole, which shall be off center and fitted with a rubber grommet, unless seal-down manholes are required.

Interior Linings for Precast Reinforced Concrete Manholes

All sanitary sewer interceptor/outfall manholes on lines 12-inches and larger, and manholes receiving a sanitary sewer force main discharge shall be internally coated with a polyurea/polyurethane coating. **Duramer 1030** shall be applied in one coat of a 20% solids, deeply penetrating, dual-component polyurea primer (0.5 – 1.0 mils dry film thickness, 150 ft^2/gal), one intermediate coat of a dual component polyurea (50-100 mils dry film thickness, 50 ft^2/gal) and one top coat of a 65% solids, two-part polyurea (7.5-10 mils dry film thickness, 125 ft^2/gal). All coats can be applied by brush, spray, or roller. **Sherflex Elastomeric Polyurethane** shall be applied according to manufacturer's recommendations. Polyurea/polyurethane coatings shall be Duramer 1030 as manufactured by SewerKote, Sherflex Elastomeric Polyurethane as manufactured by Sherwin-Williams, or approved equal.

a. Precast Reinforced Concrete Manholes

The concentric and eccentric manholes shall be designed and manufactured in accordance with ASTM C478-97. Manhole diameters shall be 4, 5, or 6 feet in diameter as determined by the table within Sewer Design standards for main size or depth. The walls shall be a minimum of 5 inches thick and have a 6-inch minimum base. O-ring or "ram neck" joint seal shall be used for all manhole joints. All exterior joints shall be wrapped with a butyl resin sealant of 8" width. The "O" ring joint shall conform to the requirements of ASTM C443-98. A flexible rubber boot shall be supplied with the manholes to tie the pipe to the barrel section. These gaskets and clamps shall meet the requirements of ASTM C923. See Detail S-24 – S-27.

The manufacturer shall submit drawings showing the reinforcing, pipe openings and other details for approval by the Public Utilities Director. Also, the manufacturer shall provide

certified test reports indicating that the materials comply with the requirements of ASTM C478-97. "Extended base" precast sections must comply with Detail S-21 dimensions and equivalent reinforcing.

b. Related Materials

1) Manhole rings and covers shall be manufactured to the dimensions shown on the Details S-25 through S-27 and shall be made from Class 30 gray iron, meeting the requirements of ASTM A48-94ae1. All covers must be domestically cast and so indicated by manufacturer name and "USA" in castings. Covers shall have "DANGER PERMIT REQUIRED – CONFINED SPACE DO NOT ENTER" cast onto the face as shown in Detail S-25. All manhole rings on flat-top manholes shall be cast into the manhole top, as shall be the flange for the vent stack, if applicable. See Details S-24. Cam Lock covers shall be used on all manholes that are within easements. See details 24 & 27.

2) Manhole steps shall be made from reinforcing steel which is rubber plastic coated to provide for safer footing. These steps shall be furnished in accordance with the Detail S-28 and the applicable OSHA regulations. Steps shall also be provided on outside of raised manholes when top elevation is greater than three (3) feet above existing ground elevation. All traffic bearing castings must be Class 35 or greater.

3) Cement used in masonry or reinforced concrete units shall be Type I, CSA normal, meeting ASTM C150-99, unless otherwise approved by the Public Utilities Director.

4) Concrete shall be only plant-mixed or transit-mixed concrete conforming to ASTM C33-99ae1 as to aggregates and to ASTM C94/C94M-99e1 for ready-mixed concrete.

Concrete shall be of three types as based on 28-day compressive strength:

Type AA	4500 psi.
Type A	3000 psi.
Type B	2500 psi.

Concrete shall be air-entrained, unless specified otherwise, with 4 to 6% air. Retarders and accelerators shall be used only as directed by the engineer.

Concrete used for structures such as sewage lift stations and other reinforced concrete structures shall meet all applicable provisions of the NCDOT specifications regarding manufacturer, delivery and placement.

5) Steel reinforcing for concrete structures shall meet all applicable provisions of the NCDOT specifications as to manufacture, fabrication and placement.

6) Mortar used for sewer structures shall conform to ASTM specification C144-99 as to aggregate and strength. Mortar shall be prepared from cement in perfect condition and shall be prepared in boxes for that purpose. No mortar that has stood beyond forty-five minutes shall be used. Proportion by volume for different kinds of work shall be:

Brick Masonry - 1 part cement to 2 parts sand
Pointing - 1 part cement to 1 part sand

7) Rubber boot sleeves shall meet or exceed ASTM C923 for connecting pipes to thru the barrel section of the manhole. Boot sleeves shall have stainless steel expansion bands and pipe clamps that meet or exceed ASTM C923 and A167.

8) Manhole inverts shall be constructed with a width equal to that of the effluent pipe, height to the springline and invert "shelves" from that point upward at a 60 deg. angle to the manhole walls. The invert shall be brushed and troweled that a minimum energy loss occurs in the manhole from invert roughness. "Bowl" shaped invert will not be allowed.

7. MISCELLANEOUS MATERIALS

a. PVC Sewer Service Pipe

PVC sewer service pipe shall be schedule 40 PVC including the clean-out stack provided that a bronze clean-out slotted plug for location purposes.

b. PVC Sewer Pipe and Saddles

PVC sewer pipe, saddles and adapters shall conform to the requirements of ASTM D3034-98. The saddle shall be installed in accordance with Standard Details S-31 and S-32.

c. Sewer Air Release/Vacuum Breaker Valve Material

Air release/vacuum breaker valves on sewer force mains shall be in accordance with Detail S-9.

d. Concrete Structures and Access Hatches

All other concrete structures and access hatches installed within highway right of ways shall be H-20 load rated.

CONSTRUCTION SPECIFICATIONS FOR SEWER MAINS

As part of the requirement to obtain construction approval for sewer main extensions, the engineer shall affix the appropriate permit sticker to the original drawings. The various permit stickers are included in appendix D.

The requirements contained in this section shall apply to sanitary sewer main installations constructed for the Public Utilities Department or for private developers who may or may not dedicate the sewer improvements to the City. All necessary construction permits must be obtained before construction may begin in accordance with the North Carolina State Law. A sewer plug permit must also be obtained.

Any Contractor performing work within the City of Raleigh or City of Raleigh Merger Areas such as Garner, Knightdale, Wendell, Zebulon, Wake Forest, and Rolesville , shall have on each job site a copy of these specifications.

1. SCOPE OF WORK

a. The contractor shall furnish all materials, equipment, and labor for excavation, installation, backfilling of sewer mains and related appurtenances as shown on the plans. The Public Works Department and/or Public Utilities Department shall conduct all City inspections on main extension projects.

b. It shall be the contractor's responsibility to notify the Public Utilities and Public Works Departments at least twenty-four hours in advance of beginning any construction work on any project. The contractor must call the Public Utilities Department at 996-4540 and Public Works Department at 996-6810 and give the location, project name, individuals name, company name, start date and indicate if it involves a sewer extension and state the start date. Contractors must call the Public Utilities Inspections staff at 996-2737 at least twenty-four hours in advance for an inspection in the Garner, Knightdale, Wendell, Zebulon, Wake Forest, and Rolesville Utility area.

c. Once construction has begun, the contractor shall contact Public Works at 890-3030 each morning by 9:00 a.m. to notify where and what will be done that day. The City requires a 24 hour notice prior to an inspection. Any work requiring inspector's observation outside of the normal work day, shall be charged at the current inspector hourly rate.

d. In all **Sewer Bypass Pumping** operations, a bypass plan sealed by a N.C. Professional Engineer must be submitted for approval to the Public Utilities Department prior to pumping operations (Plans may be submitted to administration staff at One Exchange Plaza, Suite 620, Raleigh, NC 27601) Pumps should be sized to handle the peak daily flow (2.5 times the average daily flow) for the line or area of work. The contractor shall secure pumps from a pump supplier according to the provided flow information. Pumping operations must be monitored 24 hours a day for each day of the pumping operation by qualified personnel in order to respond to problems or failures. 100% redundancy is required for pumping operations. In addition, back up pumps are to be connected to the bypass force main to facilitate immediate use upon failure of the primary pumps. Sewer service outages must be scheduled one week in advance and may not last longer than eight hours.

e. If a developer, engineer or contractor proceeds with the main installation prior to permit issuance the City requires the main to be reinstalled and the developer, engineer or

contractor shall be fully liable for all actions and costs, including prosecution by the City or the State for proceeding with installation prior to issuance of appropriate permit(s).

f. "Field changes" are not considered approved by the Public Utilities Department unless revised plans have been submitted to the Public Utilities Department, reviewed and approved. Therefore, the contractor that proceeds with construction prior to this approval is at his/her own risk.

g. Contractors working (excavation, boring, or other subsurface breach) around or in the vicinity of sewer force mains 8 inches in diameter or larger shall be required to physically spot the existing line to be verified by P.U.D. distribution staff or inspection staff. If other existing lines sizes are in question of conflict the contractor shall be directed by P.U.D. staff of the level of subsurface investigation needed to locate the existing line.

2. GENERAL TESTING REQUIREMENTS

a. The City may perform and shall require the contractor to perform, such destructive and nondestructive testing, as it deems necessary in order to inspect the materials and workmanship. See specific testing requirements within this section. These tests shall be in accordance with the procedures established by ASTM and AASHTO. The City shall reserve the right to modify the procedures in testing ditch and backfill compaction to allow a deeper test to be made by using the sand-cone method and/or nuclear testing gauges.

b. All new sanitary sewer mains must be cleaned to the satisfaction of the inspector by jetting or balling prior to final inspection and acceptance by the City.

c. Prior to final inspection all sanitary sewer mains shall be camera inspected. In areas where the manholes are installed within the street, the camera inspection shall take place just prior to the final lift of surface course asphalt. Failed inspections will require a follow up inspection and subsequent re-inspection fee.

3. SEWER CONSTRUCTION PLUGS

a. A sewer plug permit must be obtained prior to beginning construction. See General Policies and Regulation Section for application.

b. Mechanical plugs (non-pneumatic) must be installed for the duration of construction of any sanitary sewer extension. Plugs are to be installed on the upstream end of the new main at the first manhole from the existing tie-in, until final acceptance.

c. All plugs must be securely tied off with steel cable within the manhole and must have a secure marking attached to the plug indicating the utility contractor to whom the plug belongs.

d. All plugs must be monitored during construction to insure the plug is functioning as required.

e. Prior to removing the plug, the contractor must sign a plug removal form verifying that the sewer facilities are sufficient and functionally complete. All plugs must be removed by the contractor upon acceptance that the sewer facilities are sufficiently functionally complete

to accept flow and PRIOR to the mains above the plug location being placed into service and/or accepting any flow of sewage.

4. HANDLING AND STORAGE OF MATERIALS

a. The contractor shall be responsible for the shipping and storing of all sewer materials. Any material which is damaged or defective shall be replaced by the contractor at the contractors' own expense.

b. The loading and unloading of all pipe, manholes and other accessories shall be in accordance with the manufacturer's recommended practices and shall at all times be performed with care to avoid any damage to the material.

c. The contractor shall locate and provide the necessary storage areas for materials and equipment. If private property is being used for storage areas, then the contractor must have the written consent from the owner. Without this written consent, all material and equipment shall be stored within the existing rights-of-way and easements of the project. Pipe may not be prestrung along job site; it must be delivered to and removed from job site each day.

d. All materials, once on the job site, shall be stored in accordance with the manufacturer's recommendations. All PVC sewer pipe shall be protected from the sun's ultra violet rays if stored on the job site longer than twenty days.

e. All pipes shall be kept free of dirt and other debris. Any damage relating to the coating of the various materials for sewer and water mains shall be repaired in a manner approved by the City. Machined manhole frames and covers shall remain intact until construction is complete.

f. The contractor shall be responsible for safeguarding and protecting all material and equipment stored on the job site. The contractor shall be responsible for the storage of materials in a safe and professional manner to prevent injuries, during and after working hours, until the project is complete.

5. BARRICADES, SIGNS AND STREET PROVISIONS

a. Signs, barricades, warning lights, guard rails and flaggers shall be employed as necessary when construction endangers either vehicular or pedestrian traffic. These devices shall remain in place until the traffic may proceed normally again. The contractor shall hold the City harmless for any damages or injuries caused by the construction of sewer mains.

b. Detours shall be set up and maintained by the contractor under the direction of the City of Raleigh Department of Transportation and North Carolina Department of Transportation. Notice must be given a week in advance of the detour so that necessary notification of the traveling public may be made. The contractor will furnish all barricades, signs, lights and other safety devices to protect his/her construction. The contractor is in no way relieved of liability for providing this protection because the detour is approved by others.

c. Construction work zone signs and signing procedures shall conform to the MUTCD and supplements and to all applicable federal, state and local codes. The contractor shall be responsible for securing the necessary permits from the City's Transportation and

Inspections Departments for all work to be performed in the public rights-of-way.

6. PROPERTY PROTECTION

Trees, fences, poles and all other property shall be protected unless their removal is authorized, and any property not authorized for removal, but damaged by the contractor, shall be restored by the contractor to the owner's satisfaction. Existing manholes within the work zone and outside of the pavement shall be protected by orange safety fence.

7. GENERAL CONSTRUCTION SAFETY

a. The contractor and any subcontractors shall be responsible for the total compliance with all federal, state and local ordinances, laws and regulations as related to safe construction practices and to protecting the employees and the public's health and safety.

b. The contractor shall ensure that all Occupational Safety and Health Administration (OSHA) regulations and standards are followed during all phases of the construction project.

c. The City shall not be responsible for contractor’s adherence to OSHA regulations and standards. However, the City may report known violations or unsafe practices to the appropriate enforcement agency.

d. The contractor shall furnish safety equipment necessary to inspect the work including, but not limited to ladders, gas detectors/oxygen sensors, blowers, etc.

8. ENCROACHMENT CONTRACTS AND PERMITS

a. Prior to actual construction, the contractor shall acquire the necessary encroachments from NCDOT when working within the rights-of-way of state system roads or highways. The encroachment permit shall be kept on the job site at all times.

b. The contractor shall be responsible for securing all other local and state and federal permits required for the utility construction. The contractor must have an approved set of permitted construction plans on site at all times.

c. The contractor must have an approved set of permitted construction plans on site at all times.

d. For projects which require construction plan approval, all environmental permits and NCDOT encroachments must be provided prior to plan approval. See general policies and regulations section Page 25.

9. PAVEMENT REMOVAL AND REPLACEMENT

a. Any pavement that must be removed shall be cut along straight lines with the appropriate saw cut machine. A street cut permit is required. The removal and replacement of the pavement shall conform to the information shown in Details S-1 thru S-4.

b. All cuts of City streets must be patched the same day with a temporary or permanent patch. Once work has been completed, all temporary patches shall be replaced with permanent ones. All work from patching shall be cleaned up at the same time of patching

c. The City of Raleigh shall perform density tests as needed to determine contractor's compactive efforts. See Notes 2 and 3 of details S-3 & S-4.

d. Pavement cuts shall be confined to a maximum trench bottom width as shown in Details S-4 & S-5, plus 12 inches on either side.

e. Asphalt compaction shall be done with a gasoline or diesel powered smooth drum asphaltic roller.

f. Pavement cuts within NCDOT Right of Way shall not be performed without the proper encroachment permits on site. All patching of NCDOT pavements shall conform to the approved on site encroachment permit.

10. EXCAVATION

a. Prior to any excavation or construction, the contractor shall locate all existing utilities in the field. If help is needed in locating utilities operated by the Public Utilities Department, the contractor should contact the Operations Division (996-2737).

b. Trench width shall be a minimum of twelve inches plus outside diameter of pipe and a maximum of twenty-four inches plus outside diameter of pipe, unless additional trench width is required by OSHA. Trench width shall be measured between the faces of the cut at the top elevation of the pipe bell as shown in Details S-4 & S-5.

c. Trench bottom conformation, where no special bedding is required, may be that referred to herein as flat bottom where the trench bottom is excavated slightly above grade and cut down to pipe grade by hand in the fine-grading operation. Where the trench bottom is inadvertently cut below grade, it shall be filled to grade with an approved material and thoroughly tamped.

d. The maximum length of open trench shall be no more than three-hundred feet unless approval is obtained from the Public Utilities Director.

e. The contractor shall, at the contractor's own expense, keep all trenches free from water during the excavation for construction of sewer mains. The water shall be pumped out of the trench or build check dams to keep it out of the ditch in such a manner as not to cause injury to the public health, private property or the work in progress. Erosion control measures shall be taken during this pumping.

f. In trenches where water is present or dewatering is required, the trench shall be stabilized with #67 stone. When the contractor encounters material during trench excavation, at the opinion of the inspector or Public Utilities Director, that is unsuitable (i.e. "muck"), this material shall be replaced with material that is considered suitable prior to the pipe laying operations. In this case, construction fabrics may be required to prevent the migration of side support away from the pipe.

g. Safety and convenience of the public necessitate that all work, including excavation, be done in such a manner as to cause minimum traffic interruption, both pedestrian and

vehicular. Utilities such as fire hydrants, valves, etc., shall be accessible at all times. Gutters and drains shall be left open and clear at all times, and the contractor shall be responsible for all drainage around his work. Unless specifically waived by the Public Works Department, provisions shall be made to maintain vehicular traffic on all streets in which work is in progress, and suitable walkways shall be maintained for pedestrian travel.

h. Sheeting or bracing shall be used wherever necessary to prevent failure of the trench banks. All sheeting shall conform to AASHTO and OSHA safety standards. The decision of the Engineer relative to bracing for the protection of property of the City shall be binding upon the contractor. The removal of sheeting shall be done in such a manner as to minimize the loss of friction between the backfill and trench walls

11. ROCK EXCAVATION

a. Rock shall be defined as that solid material that cannot be excavated, in the opinion of the Public Utilities Director or Engineer, by any means other than drilling and blasting, drilling and wedging, or boulders and broken concrete exceeding ½ cubic yard in volume. Rock shall be excavated to the same limits as earth excavation except that the trench shall be made six inches lower than the outer bottom of the pipe, and this six inches shall be refilled with six inches of #67 stone and thoroughly compacted to the sub-grade level. All blasting shall be done after coordination with the City Inspector and subject to all applicable regulations. The City reserves the right to require the removal of rock by means other than blasting where any pipe or conduit is either too close to or so situated with respect to the blasting as to make blasting hazardous. Rock taken from the ditch shall immediately be hauled away and disposed of by the contractor.

b. Blasting procedures shall conform to all applicable local, state and federal laws and ordinances. A blasting permit shall be obtained from the City of Raleigh Fire Marshal's Office, prior to any blasting. The application shall be obtained 24-hours before any blasting takes place, and the Fire Marshal may specify the hours of blasting. The contractor shall take all necessary precautions to protect life and property, including the use of an approved blasting mat where there exists the danger of throwing rock or overburden. The contractor shall keep the explosive materials that are on the job site in specially constructed boxes provided with locks. Failure to comply with this specification shall be grounds for suspension of blasting operations until full compliance is made. No blasting shall be allowed unless a galvanometer is employed to check cap circuits. Where blasting takes place within five-hundred feet of a utility, structure or property which could be damaged by vibration, concussion or falling rock, the contractor shall be required to take seismograph readings and to keep a blasting log containing the following information for each and every shot.

1) Date of shot
2) Time of shot
3) Crew Supervisor
4) Number and depth of holes
5) Approximate depth of overburden
6) Amount and type of explosive used in each hole
7) Type of caps used (instant or delay)
8) The weather
9) Seismograph instrument and readings

c. This blasting log shall be made available to the Public Utilities Director or Engineer upon request and shall be kept in an orderly manner. It shall be the contractor's responsibility to have adequate insurance to cover any damages resulting from blasting so to save the City of Raleigh harmless from any claims.

12. TRENCH PREPARATION

a. Trench excavation shall conform to the line and depth shown on the plans. The trench shall be properly braced and shored so that workers may work safely and efficiently. When water is being pumped from the trench, the pump discharge shall follow natural drainage channels, drains or storm sewers. In no case may trench water or groundwater be pumped into or allowed to enter the sanitary sewer system. See erosion control section for appropriate siltation prevention measures prior to pumping.

b. The width and type of trench may vary with the depth of cut, and the trench shall be constructed in accordance with the dimensions and other information shown on Details S-4 & S-5.

c. Pipe Clearance in rock shall be a minimum of six inches on each side and bottom for mains fifteen inches in diameter and less. For larger size mains, the minimum clearance shall be nine inches on the sides and bottom.

d. If unstable conditions are encountered, the trench shall conform to the requirements as stated in this Handbook.

13. PIPE INSTALLATION

a. The pipe material listed above shall be installed in accordance with the manufacturer's recommendations and the requirements of these specifications.

b. All sewer mains and manholes shall be laid to the line and grade shown on the plans.

c. No deviations from line and grade shall be made, unless they have been approved by the Public Utilities Department or Engineer and identified on the "as-builts".

d. The sewer pipe installation shall start at the outlet end and proceed upstream to the termination of the project as shown on the plans. The bell ends shall point upstream. Exceptions to this provision will be considered on a case by case basis, when requested in writing by the owner of the development at the time engineering construction plans are submitted to the City for review and approval. The development owner must agree to hold the City harmless. He must accept full responsibility for compliance with state and federal regulations of the Clean Water Act, including any associated penalties which could reach up to $25,000/ day, for the release of wastewater from sanitary sewer to the environment, which are not connected to existing sewer due to the granting of an exception to the pipe laying sequence required in the Public Utilities Handbook. The development owner must further agree to not request building permits, if an exception is granted for that portion of the development, until connecting sewer is constructed and accepted by the City.

e. While working on any part of an existing sewer main, the contractor shall maintain the existing sewage flow. No discharge of sewage to the storm waters will be allowed. Water for the flushing of new sanitary sewer mains must be obtained through a fire hydrant meter and must be pumped out and may not be discharged into the sanitary sewer system. Construction requiring existing sewer flow to be pumped from existing manholes shall be the responsibility of the contractor and must be approved prior to proceeding by the Public Utilities Director or the City Inspector according to Section 1. d., Scope of Work for Bypass Pumping.

f. After the trench foundation has been properly graded with bell holes, the pipe shall be carefully lowered into the trench with approved methods. Under no circumstances shall the pipe or accessories be dropped or dumped into the trench. All damaged pipe shall be properly repaired or replaced at the contractor's expense.

g. The pipe interior shall be kept clean before and after installation by means approved by the Public Utilities Director or Engineer. Pipe ends shall be plugged at the end of each workday or when work is temporarily stopped. The plugs shall be watertight so the water and debris will be kept out.

h. When installing a sewer main, the horizontal separation from any water main shall be ten feet. If this separation cannot be maintained due to existing conditions, the variation allowed is the water main in a separate trench with the elevation of the water main at least 18 inches above the top of the sewer and must be approved by the Public Utilities Director. All distances are measured from the outside diameter to outside diameter. Where it is impossible to obtain proper separation, or anytime a sanitary sewer passes over a water main, DIP materials or steel encasement extended 10' on each side of crossing must be specified & installed to waterline specifications.

i. Maintain 24" min. vertical separation at all sanitary sewer & storm drain crossings. Where adequate separations cannot be achieved, specify DIP materials & a concrete cradle having 6" min. clearance (per COR PUD detail S-49)

j. All other underground utilities shall cross water & sewer facilities with 18" min. vertical separation required

k. Railroad crossings shall be made following all precautionary construction measures required by the railroad officials.

l. All sewer crossings under state system roads shall be made in accordance with the requirements of NC DOT as defined in their encroachment permits.

m. Where conditions are, in the opinion of the Public Utilities Department or Engineer, unsuitable for laying pipe because of weather or trench conditions, the Contractor shall be required to cease work until permission is given by the Public Utilities Director or Engineer for work to commence again, providing such conditions have been corrected.

14. LAYING CCFRPM GRAVITY SEWER PIPE

All CCFRPM pipe shall be installed per manufacturer recommendations and the following requirements:

a. Do not exceed forces recommended by the manufacturer when joining pipe.

b. Gasket shall be wiped clean prior to joining. Damaged, defective, or bulging gaskets shall be replaced with a new coupling.
c. Wipe the plain end of pipe clean prior to insertion in the socket.
d. Apply joint lubricant, as approved by the pipe manufacturer, to pipe end and elastomeric gaskets.
e. For handing pipe, use textile slings or other suitable materials or a forklift. Use of cables or chains is not permitted. Damaged pipe will be rejected.
f. Pipe shall be free of nicks, scratches, and gouges at the time of installation. Visible gouges shall be cause for rejection of pipe.

For depths of cover of 0' to 40' CCFRPM pipe shall be bedded in a minimum of 6" Class I material. Embedment and initial backfill shall be Class I material to 6" above the top of pipe. Backfill the remaining 6" of initial backfill with Class I, II, or III material. See Detail S-1.

15. LAYING PVC GRAVITY SEWER PIPE

The foundation for PVC gravity sewer pipes shall be a firm flat bottom trench of 4 inches of Class I material as defined in ASTM D2321-89(1995) compacted with bell holes. See Details S-2, S-3, & S-5. Class II material may be used if contractor can verify that this type of soil is native to the site by having soil tests made by a soil testing agency. Sample borings shall be taken on 200 feet intervals and to a depth equal to our greater than the trench bottom shown on the plans. The results must be approved by the Public Utilities Director prior to pipe installation.

16. LAYING PVC FORCE MAIN PIPE

Install C900 and C905 PVC pipe in conformance with AWWA C605. Clean bell and spigot ends prior to jointing. Ends of field cut pipe shall be beveled with file. Gasket shall be clean and lightly lubricated. Joint shall be made as recommended by the manufacturer.

17. LAYING DUCTILE IRON SEWER PIPE

a. Ductile iron pipe shall be installed in accordance with the requirements of AWWA Standard C-600. See Detail S-4.

b. Sewer pipe shall be laid to the line and grade shown on the plans. There shall be a minimum horizontal separation between water and sewer utilities of ten feet and a vertical separation of 18 inches.

c. Protection shall be afforded to all underground and surface structures using methods acceptable to the Public Utilities Director or Engineer. This protection shall be furnished by the contractor at the contractors' own expense.

d. Deviation from line and grade may be made on revised plans upon approval by the Public Utilities Department and identified on "as builts" when such deviations arise from grade or line conflicts with existing utilities, structures or other sources of conflict.

e. Subsurface explorations shall be made by the contractor at the direction of the Public Utilities Director or Engineer where it is necessary to determine the location of existing pipes, valves or other underground structures.

f. Depth of pipe cover, unless shown otherwise on the plans shall be a minimum of three feet outside of travel ways and five feet inside of travel ways. Depth of cover shall be

measured from the established street grade or the surface of the permanent improvement to the top of the barrel of the pipe.

g. After the foundation has been properly graded, bedded when applicable, and the bell holes dug, the pipe and accessories shall be carefully lowered into the trench by approved methods. Under no circumstances shall the pipe or accessories be dropped or dumped into the trench. All damaged pipe and accessories shall be removed from the job. All damaged pipe shall be replaced at the expense of the contractor.

h. installation of pipe and jointing of pipe shall be done according to manufacturer's recommendation with care being taken to provide uniform bearing for the pipe. Bell and spigot of pipe shall be cleaned and properly lubricated where a mechanical joint of a "push on" type joint is employed.

i. Open ends of pipe shall be plugged with a standard plug or cap at all times when pipe installation is not in progress. Trench water shall not be permitted to enter pipe.

j. Bell ends will face the direction of installation which must be upgrade unless otherwise directed by the Public Utilities Director or Engineer.

k. Where conditions are, in the opinion of the City Inspector, unsuitable for pipe installation because of weather or trench conditions, the contractor shall be required to cease work until permission is given by the City Inspector for work to commence again providing such conditions have been corrected.

18. INSTALLING CIPP LINER

Installation Preparations

Adhere to the methods listed below to produce a high quality rehabilitated pipeline by the cured-in-place inversion method. The finished product is to be of highest quality and shall eliminate infiltration problems which exist in the existing wastewater pipeline.

Installation Preparation: The following installation preparation procedures shall be adhered to by the Contractor.

a. Cleaning of Sewer Line: Remove debris from the sewer line in accordance with Public Utilities standards

b. Inspection of Pipelines: perform inspection of pipelines shall be by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television. Carefully inspect the interior of the pipeline to determine the location of conditions which may prevent proper installation and it shall be noted so that these conditions can be corrected. Internal T.V. inspection shall be in accordance with Public Utilities standards

c. Bypassing Sewage: Provide for the flow of sewage around the section or sections of pipe designated for reconstruction. The bypass shall be made in accordance with City of Raleigh Standards set forth in this handbook.

d. Line Obstructions: Clear the line of obstruction such as solids, dropped joints, protruding service connections or collapse pipe that will prevent the installation. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then make a point repair excavation to uncover and remove or repair the obstruction. Such excavation shall be approved in writing by the engineer prior to the commencement or the work.

Installation Procedure

a. Designate a location where the reconstruction tube will be vacuum impregnate prior to the installation. Allow the engineer to inspect the materials and "wet-out" procedure. Use a catalyst system compatible with the resin and reconstruction tube.

b. The wet out reconstruction tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. Insert the reconstruction tube into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the reconstruction tube shall be turned inside out and attached to the standpipe so that a leak proof seal is created. The inversion head will be adjusted to be of sufficient height to cause the impregnate tube in the invert from manhole to manhole and hold the tube tight to the pipe wall, produce dimples at side connections and flared ends at the manholes. The use of a lubricant is recommended. Care shall be taken during the elevated curing temperature so as not to overstress the felt fiber. In certain cases, the contractor may elect to use a top inversion where the reconstruction tube is attached to the top ring and the standpipe is formed from the reconstruction tube itself.

c. Curing: After inversion is competed, supply a suitable heat source and water recirculation equipment. Equipment shall be capable of delivering hot water throughout the section by means of a pressuring hose to uniformly raise the water temperature above the temperature required to affect a cure of the resin. The temperature shall be determined by the resin\catalyst system employed.

d. Fit heat source with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Place a gauge between the impregnated reconstruction tube and the pipe invert at the remote manhole to determine the temperature during cure. Water temperature in the line during the cure period shall be as recommended by the resin manufacturer. Initial cure shall be deemed to be completed when inspection of the exposed portion of cured pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exothermic. The cur period shall be of a duration recommended by the resin manufacturer, as modified for the cured in place inversion process, during which time the recirculation of the water and cycling of the heat exchanger to maintain the temperature continues.

e. Cool down: cool the hardened pipe to a temperature below 100° F before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

f. Finish: the finished pipe shall be continuous over the entire length of an inversion run and be as free as commercially practicable from vision defects such as foreign inclusions, dry spots, pinholes and delaminating.

g. Sealing pipe at manholes: if due to broken or misaligned pipe at the manhole wall, the new pipe fails to make a tight seal, apply the seal at that point. The seal shall be of a resin mixture compatible with the pipe.

h. Service connections: Fully reopen the existing active service connections in each length of sewer following lining. Reopen service connections from inside the sewer by means of a closed-circuit television camera, controlled cutting device appropriate for CIPP lining and the rehabilitates sewer pipe. Clean and neatly cut openings flush with the lateral pipe. Liner penetrations of openings shall be watertight.

i. Air test and Camera the main per specifications below.

19. SEWER LATERALS

a. Pipe for 4 inch sewer laterals shall be PVC pipe or DIP. Where installation by boring is specified, four-inch ductile iron pipe shall be used. DIP (4"only) must be used for deep or shallow installations under the same standards as sewer mains. Aerial service installations shall be constructed of 4" DIP. A minimum grade of 1% shall be maintained with four and six-inch pipe. Each lateral shall be sealed at the end with an approved watertight plug. Lateral installation for four-inch services shall conform to Standard Detail S-30. A six-inch service lateral must connect to a manhole. All laterals shall be left exposed until the inspectors can verify the installation of each plug.

b. Each sewer lateral shall be installed from the main to the street right-of-way line or easement line where a one piece combination wye and 1/8 bend and cleanout stack will be installed. The wyes on the laterals shall be sealed at the property line with a permanent plug.

c. Trench support, bedding and backfill for laterals shall conform to the same specifications as those for sewer mains. Class II, III, and IV materials may be used for PVC sewer lateral bedding in lieu of Class I materials. The contractor shall properly backfill under all wye and lateral connections at the main. The lateral connection at the main shall be backfilled with #67 stone.

d. Where laterals are bored, the face of the bore cut shall be a distance of five feet from the edge of the pavement on either side, unless approval to the contrary is given by the Public Utilities Director.

e. Sewer laterals four inches in diameter shall be connected to the main by means of an in-line wye or a tap and saddle, installed over a hole cut in the top quadrant of the main at an angle of forty-five degrees, with respect to direction of flow. The hole shall be cut with a mechanical circle type saw cutter designed for the particular use and rendering a smooth, uniform cut with no damage to the main and which retrieves the coupon. See saddle installations on Standard Detail S-31.

f. All 4" sewer services may be tapped directly into 8, 10, and 12-inch mains or manholes in accordance with Details S-31 and S-32. Taps can only be made by using a mechanical tapping machine or other approved device. All sanitary sewer service connections 6 inches and larger shall be made into manholes only. Service connections on mains 15 inches and larger are only allowed at manholes. Service clean-outs shall be located at the right-of-way line or the easement boundary line. The maximum vertical drop for a 6-inch service into a manhole shall be 10 feet.

g. All laterals tapped on newly constructed mains shall be air tested with the main. All laterals tied to a newly constructed manhole shall be vacuum tested with the manhole or conduct a separate air or water head test before any plumber connections are made.

20. MANHOLES

a. Manhole dimensions shall conform to those shown on Detail S-24. Manholes on all lines twelve inches in diameter or smaller shall have an inside diameter of four feet.

b. Inverts shall be constructed with a width equal to that of the effluent pipe, height to the springline and invert "shelves" from that point upward at 60 deg. to manhole walls, it shall be so brushed and troweled that a minimum energy loss occurs in the manhole from invert roughness. The maximum grade on an invert of less than 2.5 feet shall be no greater than 6 inches across the manhole. "Bowl" shaped inverts shall not be allowed in the sanitary sewer collection system. What is this trying to achieve?

c. Foundation for manholes shall be in accordance with Detail S-21, unless approval to the contrary is given by the Public Utilities Director.

d. All manholes in road right–of–ways will be flush with grade not withstanding 100 year flood requirements. In easements, manholes will be a minimum of 12 inches above ground.

e. All new manholes must be vacuum tested in accordance with the following procedure:

1) The Contractor shall furnish all labor, equipment, and any appurtenant items necessary to satisfactorily perform the vacuum test. All equipment will be approved for vacuum testing.

2) All lifting holes shall be plugged with an approved non-shrink grout.

4) All pipes entering the manhole shall be plugged. The contractor shall securely brace the plugs to keep them from being drawn into the manhole. All service connections tied to manholes shall also be vacuum tested with the manholes.

5) The test head shall be placed inside the top of the cone section of the manhole and the seal inflated in accordance with the manufacturer's recommendations.

6) Manhole vacuum tester shall be as manufactured by Cherne Manhole Testing or approved equal. A vacuum of 10-inches of mercury shall be drawn and the vacuum pump shut off. Inflate the compressor band to effect a seal between the vacuum base and the manhole cone section. Connect the vacuum pump to the outlet port with the valve open. With the valves closed, the time for the vacuum to drop to 9-inches of mercury shall not be less than that shown in the following table.

Manhole Depth	**Diameter of Manhole**		
	48"Dia.	**60" Dia.**	**72" Dia.**
10 Ft. or Less	60 Sec.	75 Sec.	90 Sec.
>10 Ft. but <15 Ft.	75 Sec.	90 Sec.	105 Sec.
>15 Ft.	90 Sec.	105 Sec.	120 Sec.

(Times shown are minimum elapsed times for a drop in vacuum of 1-inch of mercury).

7) If the manhole fails the initial test, necessary repairs shall be made with an approved non-shrink grout while the vacuum is still being drawn. Retesting shall proceed and continue until a satisfactory test is accomplished.

f. All manhole rings on manholes other than flat-tops shall be bolted to the cone section and sealed down with asphaltic cement or "ram-neck. See Detail S-25.

g. All manhole joints must be waterproofed with asphaltic cement or "ram-neck". All exterior joints shall be wrapped with a butyl resin sealant of 8" width.

h. All main and service pipe connections into manholes must be cored with a concrete coring machine and the pipe connection must be made with a flexible rubber boot.

i. Adjustment rings used within streets shall be fixed with mortar or a urethane based manhole joint seal by A.I.T. or approved equal.

21. BACKFILLING

a. The backfilling of the trench after the pipe installation and testing shall be in accordance with Details S-4 & S-5 & S-1 for the various pipe materials.

1) For depths of cover of 0' to 40' CCFRPM pipe shall be bedded in a minimum of 6" Class I material. Embedment and initial backfill shall be Class I material to 6" above the top of pipe. Backfill the remaining 6" of initial backfill with Class I, II, or III material. See Detail S-1.

2) The haunching for PVC pipes shall be with #67 stone (Class I material) 4 inches below and up to the springline of the pipe. Care shall be taken to work the haunching well under the bottom of the pipe. The initial and final backfill shall be with suitable native material. No rocks, boulders or stones four inches or larger shall be included in the backfill. The haunching shall be tamped to 95% standard Proctor density in six-inch lifts.

3) For PVC sewer installations, Class II material may be allowed for the bedding, housing and initial backfill if the contractor can verify that this type of soil is native to the site by having soil tests made by a soil testing agency. Soil sample borings shall be taken as directed by the City inspector to a depth equal to or greater than the trench bottom elevation shown on the plans or in the specs. The results must be approved by the Public Utilities Director prior to pipe installation. The bedding and backfilling shall be in conformance with ASTM standards and the various soil classes are defined below:

(a) Class I - Angular, 6 to 40mm (1/4 to 1 1/2 inch), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone and crushed shells.

(b) Class II - Coarse sands and gravels with maximum particle size of 40mm (1 1/2 inch), including variously graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW and SP are included in this class. (GW - well graded gravel, GP - poorly graded gravel, SW - well graded sand, SP - poorly graded sand.)

(c) Class III - Fine sand and clay type gravels, including fine sands, sand-clay mixtures and gravel-clay mixtures. Soil Types GM, GC, SM and SC are included in this class. (GM - silty gravel, GC - clayey gravel, SM - silty sand, SC - clayey sand.)

(d) Class IV - Silt, silty clays and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH and CL are included in this class. These materials are not recommended for bedding, haunching or initial backfill on PVC pipes. (MH - silty soil with high liquid limit, ML - silty soil with low liquid limit, CH - clayey soil with high liquid limit, CL - clayey soil with low liquid limit.)

4) All backfill shall be compacted in six-inch lifts measured from the foundation to one foot above the top of the pipe and then in twelve-inch lifts to the top of the trench when in easements. Sewer mains in street rights-of-way shall be compacted in six-inch lifts all the way to the top of the trench.

5) Material for backfilling shall be approved by the inspector. In areas where settlement or bearing capacity are not a major consideration, the engineer may give permission for a low grade of material to be backfilled from a point two foot above the top of the pipe, but in no event will excavated rock larger than four inches at any point be used for backfill material.

6) Where backfill material is unsuitable, in the opinion of the Public Utilities Director or Engineer, the contractor may be directed to dispose of the unsuitable material and provide material suitable to the Public Utilities Director or Engineer.

7) All backfill shall be compacted in six-inch lifts measured from the pipe foundation upward. Backfill for roadway shall be compacted to at least 95% of maximum soil density in those areas where the supporting capacity of the soil is of prime consideration. Laboratory determination of maximum soil density will follow the procedure of AASHTO T99-86. Field determination of the density of the soil in place shall follow the procedure of AASHTO T191-86 or T204-86. The result of any one test may be a minimum of 90% of maximum density, but the average of any three tests in an area shall be 95% of maximum density. All tests shall be conducted at the direction of the City Inspector, and the cost of such tests will be borne by the contractor with the provision that the City will test an area two times only where both tests fail. The contractor shall then be required to submit satisfactory evidence that his ditch compaction meets the specifications.

PVC Forcemains

PVC pipe shall be installed in accordance with AWWA C605. At a minimum, all PVC pipe shall be installed at a Type 3 laying condition as specified by AWWA C605 for depth of installation from 4-ft to 10-ft measured from the top of the pipe. The Type 3 laying condition requires the pipe to be bedded on a minimum of 4-inches of select granular material that will conform to the bottom of the pipe. Select granular material shall consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles, and shall contain not more than 10 percent by weight of material passing a 0.075 mm (No. 200) mesh sieve and no less than 95 percent by weight passing the 25 mm (1 inch) sieve. Pipe installation on a flat bottom trench is unacceptable.

Embedment material shall be compacted to the top of the pipe. When using mechanical compactors, avoid contact with the pipe. When compacting over the pipe crown, a minimum cover of at least 8-inches or more in conformance with the manufacturer's requirements shall be maintained over the top of the pipe prior to compacting. The maximum embedment sizing shall be limited to materials passing a 3/4-inch sieve for angular materials or 1-1/2-inches for rounded rock. Embedment materials consisting of select material or native soils shall be well drained, granular, free of rocks and other foreign materials and shall be selected and placed to prevent gouges, crimping, or puncture of pipe, joints or appurtenances.

22. SURFACE RESTORATION

a. All disturbed surfaces and property thereon, shall be restored to a condition equal to that existing before construction began, and the contractor shall maintain and be responsible for all ditches in paved streets, curbs, gutters or sidewalks until the contractor repaves the trench cuts. The contractor, with permission of the inspector, may place temporary or permanent asphaltic material in the cut. Asphalt compaction shall be done with a gasoline or diesel powered smooth drum asphaltic roller.

b. All easements will be seeded with grass and left so they can be mowed by conventional mowers, unless approved by the Public Utilities Department for rip-rap or other specified material. In remote areas, easements will be seeded with a quality fescue grass. In residential areas, easements will be seeded with either falcon or rebel fescue or leaf mulch at the request of property owner. The contractor shall guarantee a good uniform stand of grass and shall reseed any bare or thin spots. The contractor will be responsible for a one-year warranty on materials and workmanship.

23. EROSION CONTROL

Erosion control measures shall be performed by the contractor, conforming to the requirements of, and in accordance with plans approved by the State of North Carolina Department of Environment and Natural Resources, North Carolina Sedimentation Control Commission and City of Raleigh Inspections Department Erosion Control Division, and as per the erosion control plan portion of the construction drawings and these specifications. The contractor shall not allow mud and debris to accumulate in the streets. The sedimentation and erosion control plan and permit shall remain on site at all times. Should the contractor pump water from trenches during construction, appropriate siltation preventative measures shall be taken prior to the entry into any storm drain or stream. All materials used for erosion control shall be approved by the Engineer prior to installation by the contractor.

a. Temporary and permanent erosion control measures shall be shown on the plans. Temporary and permanent erosion control work shall be coordinated throughout the project to provide effective and continuous erosion control throughout construction and post construction, which minimizes siltation of streams, lakes, reservoirs, other water impoundments, ground surface, or other property. Seeding and mulching shall be carried out immediately behind construction.

b. Temporary erosion control measures shall include but not be limited to swaled easements, silt fences, crushed stone check dam devices, silt basins (sedimentation traps), mulching, earth berms, and rip-rap.

c. Permanent erosion control measures shall include but not be limited to swaled easements, rip-rap, and seeding of disturbed areas.

d. Erosion and siltation shall be controlled on projects by using swales to control run-off and convey run-off to controlled discharge points, by silt fences, rip-rap, crushed stone, and earth berms to contain silt, with pipe culverts where major access or haul roads cross drainage ditches or streams, silt basins where pipe lines cross drainage ditches or streams, and seeding and mulching will be performed as soon after pipe installation as possible. When temporary measures are removed after completion of the project the disturbed area must be stabilized, if necessary.

24. MAINTAINING SERVICE

When replacing or extending sewer mains, the contractor shall maintain existing service to all property being served through bypass pumping or other means of maintaining service.

25. GUARANTEE

The contractor shall guarantee all material, equipment and workmanship for a period of at least one year after final acceptance by the City. The Public Works Department's Construction Inspection Division is responsible for the issuance of final acceptance letters by the City.

For projects in Merger Areas the Public Utilities Department Construction Inspection Division is responsible for issuance of final acceptance letters.

26. WETLAND/ STREAM BUFFERS

Conditions of 401/404 permits shall be strictly followed to the satisfaction of Corp of Engineers. All Neuse Riparian buffers shall be maintained as required by NCDWQ.

27. TEST AND INSPECTION (GRAVITY SEWERS)

a. Sewer lines shall be visually inspected from every manhole by use of mirrors, television cameras or other devices for visual inspections, and the lines shall exhibit a fully circular pattern when viewed from one manhole to the next. Lines which do not exhibit a true line and grade and have structural defects shall be corrected to meet these specifications. Manholes that are installed within the street shall be camera inspected just prior to the final lift of surface course asphalt.

b. Sewer lines will be tested by using the low pressure air test. Sewer laterals will be tested along with the main. It is imperative that proper plugs be installed on the laterals at the cleanout stack. All plugs should be properly installed to withstand the test pressure. Mechanical plugs must be installed throughout the time of construction of any sanitary sewer extension, until final acceptance. All plugs must be securely tied off with steel cable within the manhole and must have a secure marking attached to the plug indicating the utility contractor to whom the plug belongs. All plugs must be removed by the contractor upon acceptance that the sewer facilities are sufficiently functionally complete so as to accept flow and PRIOR to the mains above the plug location being placed into service and/or accepting any flow of sewage.

c. The low pressure air test in accordance with ASTM F1417 or C924 (F1417 for PVC and Ductile; C924 for Concrete Pipe) will be used on all mains and laterals. Prior to testing, the main shall be clean of debris (to the satisfaction of the inspector) and flushed with water. In doing the air test, it is necessary that plugs be secured properly and braced. In doing the air test, no person will be allowed in the main while it is pressurized. The line is to be pressurized to 4 psi initially and stabilized. After stabilization, the pressure will be decreased to 3.5 psi, and the inspector will determine how long it takes for the pressure in the line to drop to 2.5 psi.

To simplify the ASTM procedure, use the following table to determine the test time. If there are multiple sizes, add the various times together.

Normal Pipe Size (inches)	Time (Minutes/100ft.)
4	.3
6	.7
8	1.2
10	1.5
12	1.8
15	2.1
18	2.4
21	3.0
24	3.6
27	4.2
30	4.8
33	5.4
36	6.0
42	7.3

If the pressure stays between 3.5 and 2.5 psi for the test time length, the pipe is acceptable. If not, the section is not properly installed. Correct and retest.

d. A hydrostatic leakage exfiltration or infiltration test shall not exceed 100 gallons per inch of pipe diameter per mile per day for any section of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of 2 feet. All tests shall be made in the presence of the contractor or his representative and the Public Utilities Director, City Inspector or Engineer.

f. Materials and construction methods called for in these specifications are of such nature as to insure maximum protection for the sewer from infiltration. The contractor shall be responsible for the sewer conforming to the above limits for a period of one year from the date of final acceptance.

g. When sanitary sewer services are installed as a part of the same approval of the sanitary sewer mains, such as in new subdivisions/annexation areas, the air test of the sewer mains shall be performed with the services and clean-outs in place. Services tied to a newly constructed manhole shall be vacuum tested with the manhole. Services not tested with newly constructed mains or manholes shall have a separate air test before any plumber connections are made.

28. DEFLECTION TESTING FOR PVC SEWER PIPES

No sooner than thirty days after final backfill installation, a deflection test shall be executed on the sewer line. The maximum allowable deflection shall be five percent for PVC sewer pipes. The test shall use a minimum of nine pronged mandrel pulled through the pipe. The mandrel size shall be calculated by (1-allowable deflection percent) x (Base Inside Diameter). The base inside diameter is the diameter as identified in the shop drawing or advertised pipe literature. It shall not include any additional reduction pipe diameter due to manufacturing tolerances.

The contact length of the mandrel shall be at least eight inches.

Any lines not meeting this test shall be corrected by the contractor and the test repeated.

29. PIGGING (FORCE MAIN SEWERS)

All new mains with gate valves must be pigged with a polyethylene "pig", 5#/cubic foot density, at the conclusion of installation.

The pig must be blown at the end of the main by means of the following:

a. 4" main - 4" blow-off
b. 6" main - 6" blow-off
c. 8" and 12" main - blow-off assembly as shown on Standard Water Details W-21 & W-22
d. 16" – 24" main – To be determined by the field inspector

The contractor installing the line shall write the name of the company and street name in which the work is taking place on the pig in a manner in which it will not rub off.

30. HYDROSTATIC TESTING (FORCE MAIN SEWERS)

a. All main installations shall be pressure tested between each main line valve in accordance with the latest AWWA Standard C-600-87. The test shall be performed using a suitable pump and an accurate pressure gauge. Immediately upon completion of a section of main, 150 psi (± 5 psi) of pressure shall be applied and held for two hours. The acceptable leakage rate shall not exceed 0.092 gallons per inch of pipe diameter per 1,000 feet of pipe per hour.

   Failure of the force main to comply with the above acceptable leakage rate shall require the contractor to replace any defective materials to insure a watertight installation. After any inadequacies have been corrected, the leakage rate will again be tested. This test shall be repeated until that portion of main is brought to compliance with the permissible leakage rate.

b. Prerequisite conditions for inspection prior to testing shall be as follows:

   1) Valves shall be properly located, operable, and at correct elevation. Valve boxes or manholes shall be centered over operating nuts, and the top of the box or manhole shall be at proper elevation.

   2) Lines shall be properly vented where entrapped air is a consideration.

31. SEWER MAIN AND SERVICE STUB ABANDONMENT

Sewer service stub to a main shall be abandoned by removing the saddle and replacing the saddle with a 360 degree stainless steel sleeve. At in-line wyes the service lateral shall be cut within 12" of the wye and a mechanical cap installed on DIP/cast services or glued to PVC services and the abandoned wye to be surrounded with 1 ft^3 of concrete. The remaining portion of the sewer service stub shall be removed from the main to the right of way line and shall be disposed of properly. Sewer main abandonment must be performed in accordance with a plan approved by the Public Utilities Department. Service stub and main abandonment require a stub permit for inspection by the Public Works Department 919-996-4540. Raleigh Public Utilities Department will oversee stub abandonment in the merger towns 919-996-4540.

General Requirements;

- A Property owner is responsible for proper abandonment of all unused existing service stubs.
- All abandoned meters are to be removed by the Raleigh Meters Division prior to service abandonment. (919-996-2742).
- The Raleigh Public Utilities operations staff will not abandon an existing service stub unless it is part of a service renewal as required by ordinance.
- For circumstances that may not be addressed by this clarification or a variance from this procedure please contact the Raleigh Public Utilities Department Development staff at 919-996-4540.

LICENSED UTILITY CONTRACTOR REQUIRED SERVICE ABANDONMENT PERMITS

Contractor installed domestic (3/4"thru 12"), irrigation water (3/4"thru 10"), sewer (4"thru 8") and fire hydrant (6") service stub;

Commercial; All domestic and/or irrigation, sewer and fire hydrant abandonment requires a stub permit for each connection to a water or sewer main.

Residential/Individual; All domestic water and/or irrigation and sewer service stubs abandonment installation requires a stub permit. Exception; Irrigation splits installed with a new domestic service. Irrigation splits on an existing tap requires a stub permit.

Demolition Permits; Plans are required to show all existing services to be abandoned included temporary construction water using existing meter(s). Plan review required.

Sewer Stubs in Easements; A licensed and bonded utility or plumbing contractor may install a sewer stub on a sewer main located within a dedicated easement and requires the issuance of a stub permit. Raleigh Ordinance 10-6082

Street cut permits are required for pavement repair in ROW.

City of Raleigh Capital Projects

A licensed utility contractor performing City contracted water or sewer main replacement work is not required to obtain a stub or street cut permit for abandoned services or mains.

Water and Sewer Main Abandonment

All water and sewer main abandonment requires plan submittal for review by the Raleigh Public Utilities Development Staff by submission of plans through the Raleigh Development Customer Service Center

32. SEALED AS BUILT PLANS

Certified surveyed "As built" plans and profiles, sealed by a Professional Land Surveyor, shall be furnished to the Public Works Department by the engineer upon completion and acceptance of the public main by the City and at completion of private systems. For development projects in the merger towns as-builts must be submitted directly to the inspector.

34. SEWER BACKWATER VALVE

Pursuant to NC State Plumbing Code, homes and other buildings constructed with sanitary sewer drains with an elevation lower than one (1) foot above the next upstream manhole in the sanitary sewer collection system must be equipped with a sewer backwater valve, installed at a location where it can be maintained. See Details S-38 & S-42.

SECTION 33 41 00 - STORM UTILITY DRAINAGE PIPING

PART 1 GENERAL

1.1 GENERAL NOTES

A. All storm drainage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Transportation standards, and supplemented with any applicable Town of Wendell County standards. If discrepancies exist they should be brought to the Engineer’s attention immediately.

B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with NCDOT and Town of Wendell standards and specifications.

1.3 SUMMARY

A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:
   1. Pipe and fittings.
   2. inlets and outlets.

1.4 DEFINITIONS

A. RCP: Reinforced Concrete Pipe.

B. NCDOT: North Carolina Department of Transportation.

C. HDPE: High Density Polyethylene.

1.5 SUBMITTALS

A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.

B. Manufacturer’s Instructions: Special procedures required to install specified products.

C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.

D. Manufacturer's Certificate: Products meet or exceed specified requirements.

E. Qualifications Statements:
   1. Qualifications for manufacturer, and installer.
   2. Manufacturer's approval of installer.

F. Field quality-control reports.

G. Project Record Documents: Record actual locations of catch basins, drop inlets, yard inlets and grate/rim and invert elevations.

H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

A. Perform Work according to State of North Carolina Department of Transportation and the Town of Wendell standards.

B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

B. Store according to manufacturer's instructions.

C. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Owner's Representative no fewer than (72) hours in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without Owner's Representative's written permission

B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 PRODUCTS

2.1 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Pipe and Fittings: ASTM C 76. Pipe and special fittings installed with 10 feet or less cover over top of pipe shall be Class III, and all other pipe and special fittings shall be Class IV. Basis of acceptance of reinforced concrete pipe shall be the 0.01" crack.
   1. Bell-and-spigot ends and sealant joints with ASTM C 990, bitumen or butyl-rubber sealant.

2.2 PIPE OUTLETS

A. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NCDOT Section 1042 "Riprap Materials". See plans for Class/Sizing.

B. Filter Stone: According to NCDOT Section 1005 "General Requirements for Aggregate", #57 or #67 clean stone as specified on plans.

C. Energy Dissipaters: Broken, irregularly sized and shaped, graded stone according to NCDOT Section 1042 "Riprap Materials". See plans for Class/Sizing.

2.3 HDPE PIPE AND FITTINGS

D. HDPE Pipe and Fittings: All HDPE pipe shall conform to ASTM F2648 and be dual wall, smooth interior pipe with soil tight gaskets and fittings. Fittings shall conform to ASTM F2306 where applicable.

PART 3 EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are per NCDOT Standard Specifications.

3.2 EXAMINATION

A. Verify that excavations, dimensions and elevations are as indicated.

B. Check pipes for cracks or other compromising features.
   1. Any irregularities shall be reported and approved prior to installation.

3.3 PREPARATION

A. Correct over-excavation with coarse aggregate.

B. Prepare base in accordance with applicable NCDOT standard.

3.4 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and

other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Laser Equipment: Contractor shall utilize laser equipment to insure that piping is installed at elevations and slopes indicated on plans.

G. Install gravity-flow, nonpressure drainage piping according to the following:
   1. Install piping pitched down in direction of flow.
   2. Install piping at invert elevations as specified in the storm drainage table.
   3. NCDOT Standard Specifications Division 3, Section 300 or one of the following.
   3. Install reinforced-concrete piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
   4. Install HDPE Piping according to ASTM D2321 “Standard Practice for Underground Installation of thermoplastic Pipe for Sewers and Other Gravity-Flow Applications”

3.5 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:
   1. Join reinforced-concrete piping according to ACPA's "Concrete Pipe Installation Manual" or NCDOT
   2. Join HDPE piping according to ASTM and Manufacturer’s Recommendations to ensure a soil tight joint.

3.6 STORMWATER INLET AND OUTLET INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

B. Construct riprap of broken stone, as indicated.

C. Install outlets that spill onto grade, anchored with concrete, where indicated.

D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

E. Construct energy dissipaters at outlets, as indicated.

3.7 CONNECTIONS

A. Make connections to existing underground manholes.
   1. Make branch connections from side into underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of manhole, or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
      a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
      b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
   2. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may

result after ends of abandoned piping have been closed. Use either procedure below:

1. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.
2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:

1. Remove manhole or structure and close open ends of remaining piping.
2. Remove top of manhole or structure down to at least 48 inches below final grade. Fill to within 12 inches of top with stone or gravel. Fill to top with concrete.

C. Backfill to grade according to Division 31 Section "Earth Moving."

3.9 IDENTIFICATION

A. Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use identification tape or non-detectable warning tape over all underground lines outside building footprint in the backfill approximately 18” to 30” above the service pipe, but a minimum of 10” and a maximum of 24” below finished grade.
2. Use detectable warning tape over ferrous and nonferrous piping and over edges of underground manholes. Tape all underground lines outside building footprint directly on top of the pipeline and permanently secured to the pipeline at 10’ intervals.
3. Use insulated copper tracer wire or other approved conductor installed adjacent to underground nonmetallic piping and metallic pipe with compression gasket fittings installed underground. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at the end of the nonmetallic piping. The tracer wire size shall not be less than 10AWG and the insulation type suitable for direct burial. The tracer wire size shall be copper single-conductor 10AWG minimum and the insulation type suitable for direct burial with type “UF” (Underground Feeder) insulation and shall be continuous along the pipeline passing through the inside of each valve box or manhole.

3.10 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:
   a. Alignment: Less than full diameter of inside of pipe is visible between structures.
   b. Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
   c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
   d. Infiltration: Water leakage into piping.
   e. Exfiltration: Water leakage from or around piping.
3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Re-inspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

a. Exception: Piping with soil tight joints unless required by authorities having jurisdiction.
b. Option: Test concrete piping according to ASTM C 924. C. Leaks and loss in test pressure constitute defects that must be repaired.
c. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.11 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION

SECTION 33 49 13 - STORM DRAINAGE STRUCTURES

PART 1 GENERAL

1.1 GENERAL NOTES

A. All storm drainage structures, related piping and accessories shall be in accordance with the State of North Carolina Department of Transportation standards, and supplemented with any applicable Town of Wendell standards. If discrepancies exist they should be brought to the Engineer’s attention immediately.

B. Refer to construction drawings for number, location and details of all proposed structures and pipes.

1.2 RELATED DOCUMENTS

A. Materials, Installation, and Testing shall be in accordance with NCDOT and Town of Wendell standards and specifications.

1.3 SUMMARY

A. Section includes but not limited to the following items and appurtenances shown on drawings and specified in this Section:
   1. Catch Basins.
   2. Drop Inlets.
   3. Junction Boxes/Manholes.
   4. Headwalls.
   5. Accessories.
   6. Stormwater Structures.
   7. Concrete.

1.4 DEFINITIONS

A. RCP: Reinforced Concrete Pipe

B. NCDOT: North Carolina Department of Transportation.

1.5 SUBMITTALS

A. Product Data: Manufacturer information describing part, accessories, connections and any standard details.
   1. Provide back up calculations or data from the Yard Inlet and Trench Drain grates proposed.

B. Manufacturer’s Instructions: Special procedures required to install specified products.

C. Shop Drawings: Indicate Part Sizes, connection sizes, elevations and connection parts.

D. Manufacturer's Certificate: Products meet or exceed specified requirements.

E. Qualifications Statements:
   1. Qualifications for manufacturer, and installer.
   2. Manufacturer's approval of installer.

F. Field quality-control reports.

G. Project Record Documents: Record actual locations of catch basins, drop inlets, yard inlets and grate/rim and invert elevations.

H. Operation and Maintenance Data: Submit any special requirements for maintenance.

1.6 QUALITY ASSURANCE

A. Perform Work according to State of North Carolina Department of Transportation and the Town of Wendell standards.

B. Fabricator: Company specializing in fabricating products specified in this Section with three years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store according to manufacturer's instructions.

B. Protect any UV sensitive materials from sunlight by using manufacturer recommendations.

C. Handle manholes according to manufacturer's written rigging instructions.

D. Handle catch basins, drop inlets, and headwalls according to manufacturer's written rigging instructions.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Owner’s Representative no fewer than (72) hours in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without Owner’s Representative’s written permission.

B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

PART 2 PRODUCTS

2.1 CATCH BASINS

A. All catch basins to be precast in accordance with the NCDOT standard specifications.

B. Catch Basins Lids and Frames:
   1. Materials: Cast Iron
   2. Lid: Shall be in accordance with applicable NCDOT standard detail as noted.
   3. Nominal Lid and Frame Size: *Varies*, see signed construction drawings.

C. Connections
   1. All connections to be in accordance with the NCDOT standard specifications.

2.2 DROP INLETS

A. All drop inlets to be precast in accordance with the NCDOT standard specifications.

B. Drop inlet Lids and Frames
   1. Materials: Cast Iron
   2. Lid: Shall be in accordance with applicable NCDOT standard specifications.
   3. Nominal Lid and Frame Size: *Varies*, see signed construction drawings.

C. Connections
   1. All connections to be in accordance with the NCDOT standard specifications.

2.3 JUNCTION BOXES/MANHOLES

A. All drop inlets to be precast in accordance with the NCDOT standard specifications

B. Connections
   1. Connections to be minimum soil-tight.
   2. All connections to be in accordance with NCDOT standard specifications.

C. Lids and Frames:
   1. Shall be in accordance with applicable NCDOT standard specifications

2.4 HEADWALLS

A. Materials
   1. Reinforced Concrete. To be precast in accordance with the applicable NCDOT standard specifications.

B. Connections
   1. Connections to be minimum soil-tight.

2. All connections to be in accordance with NCDOT standard specifications.

C. Design
1. Design of headwall to be completed by registered Professional Engineer licensed in North Carolina.
2. Contractor to submit shop drawings to Engineer and Owner for approval. Engineer to only approve shop drawings on the basis of dimensions and size. Engineer not responsible for any footing, shoring or structural aspect of headwall.

2.5 INLINE PVC DRAINAGE BASINS (YARD INLETS)

A. Materials
1. PVC meeting ASTM D1784 standards
2. Joints meeting ASTM D3212
3. Gaskets meeting ASTM F477
4. Grates: Ductile Iron

B. Connections
1. All connections must be soil tight.

C. Sizing
1. All Inline PVC Drains and Grates must be sized to convey at least the flow shown on the Drawings.

2.6 MODULAR TRENCH DRAIN

A. Materials
1. Modular system from one single manufacturer that can provide a continuous slope trench to match the length shown on the Drawings and meet flow requirements below.
2. All grates shall be stainless steel, heel safe (per ASME A112.6.3) and meet all requirements of the American Disabilities Act.
3. Drain body should be resistant to both traffic loads and UV impacts.

B. Sizing
1. Drain and grate(s) must be sized to convey at least the flow shown on the Drawings.
2. Trench drain shall provide drain performance without the need for bypass drains or excessive ponding (more than 2”) during the flow shown on the Drawings.

2.7 ACCESSORIES

A. Any other required accessories for installation shall be engineer approved prior to installation.

2.8 STORMWATER STRUCTURES

A. Cast-in-Place Concrete, Stormwater Structures: Construct of reinforced-concrete bottom, walls, and top; according to ASTM C 890 structural loading; of depth, shape, dimensions, and appurtenances indicated.

B. Steps: Provide steps as shown on the Drawings in manholes, risers, transition cones, and transition top sections in accordance with NCDOT STD 840.66. Steps shall be spaced at 16” O.C.

C. Energy Dissipaters: Refer to Drawings for shape and sizing; Design in accordance with NC Erosion and Sediment Control Planning and Design Manual.

2.7 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:
1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.

2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
   1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
      a. Invert Slope: 2 percent through manhole.
   2. Benches: Concrete, sloped to drain into channel.
      a. Slope: 50 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
   1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
   2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

PART 3 EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are per NCDOT Standard Specifications.

3.2 EXAMINATION

A. Verify that excavations, dimensions and elevations are as indicated.

B. Check structures for cracks or other compromising features.
   1. Any irregularities shall be reported and approved prior to installation.

3.3 PREPARATION

A. Correct over-excavation with coarse aggregate.

B. Prepare base in accordance with applicable NCDOT standards.

3.4 INSTALLATION

A. Installation Standards: Install Work according to NCDOT standards and manufacturer recommendations. If discrepancies exist they should be brought to Engineer’s attention immediately.

3.5 FIELD QUALITY CONTROL

A. Request inspection by Engineer prior to back filling any aggregate.

B. If inspections indicate that Work does not meet specified requirements, remove Work, replace and request additional inspections.

C. Provide a signed and sealed as-built survey by a licensed Land Surveyor in North Carolina for all locations, lengths, sizes and inverts of all storm drainage structures and piping. Land surveyor should also indicate any and all underground utilities encountered during excavation, including elevations tied to local control.

3.6 CLEANING

A. Clean interior of structures of dirt and superfluous materials. Flush with water.

END OF SECTION