North Carolina Department of
Agriculture & Consumer Services

Eaddy Building HVAC & Lab Exhaust Upgrades & Repairs

Agronomic Services Division Laboratory

SCO ID# 22-24510-01A

Code: 42017; Item 4404

JULY 11, 2023

BID DOCUMENTS

SUBMITTED TO:

NC Department of Agriculture and Consumer Services
2 West Edenton Street
Raleigh, NC 27601
919.707.3095

SUBMITTED BY:

RMF Engineering
Reliability. Efficiency. Integrity.

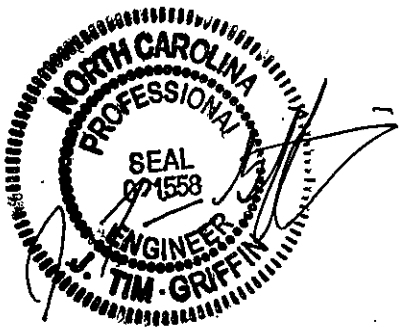
8081 Arco Corporate Dr. Ste. 300
Raleigh, North Carolina, 27617

OFFICE 919.941.9876
WEB rmf.com

DOCUMENT 00 01 07 - SEALS PAGE

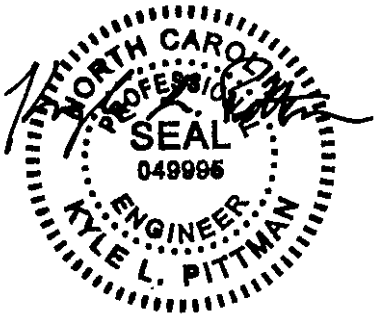
1.1 DESIGN PROFESSIONALS OF RECORD

MECHANICAL ENGINEER	**RMF Engineering, Inc.** **J. Tim Griffin, PE** **NC PE License: 021558** Specification Division 23



7/11/2023

ELECTRICAL ENGINEER	**RMF Engineering, Inc.** **Kyle L. Pittman, PE** **NC PE License: 049995** Specification Divisions 01, 26



7/11/2023

END OF SECTION 00 01 07

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DIVISION 23 – MECHANICAL

DIVISION 26 – ELECTRICAL

ADVERTISEMENT FOR BIDS

Sealed proposals will be received until 3:00PM on August 31, 2023, in Raleigh, NC, for the construction of

Eaddy Building HVAC & Lab Exhaust Upgrades and Repairs

at which time and place bids will be opened and read.

Complete plans and specifications for this project can be obtained from RMF Engineering, Inc. located at 8081 Arco Corporate Drive, Suite 300, Raleigh, NC 27617 during normal office hours after June 30, 2023.

Plan Deposit $200

The state reserves the unqualified right to reject any and all proposals.

Signed: Andrew "Andy" Meier
Director
Property and Construction Division
NC Dept. of Agriculture & Consumer Services

_____

_____

NOTICE TO BIDDERS

Sealed proposals will be received by the NC Department of Agriculture & Consumer Services in the office of Dr. Colleen Hudak-Wise, Ph.D at 4300 Reedy Creek Road – Raleigh, NC 27607 & Conference Room up to 3:00 pm August 31, 2023 and immediately thereafter publicly opened and read for the furnishing of labor, material and equipment entering into the construction of the HVAC equipment upgrades & Lab Exhaust Upgrades & Repairs for the NCDA & CS Eaddy Building.

The Work of Project is defined by the Contract Documents and includes, but is not limited to, the following:
Demolition consists of the removal of existing chiller and removal of existing roof exhaust fans along with their associated disconnect switches and power circuits; removal of the inlet guide vanes and fan motors on AHU-1A & AHU-1B and other work indicated in the Contract Documents.

New work consists of the installation of a new air-cooled chiller and redundant chilled water pump along with reworking of the chilled water piping system; installation of new roof exhaust fans, rework of the existing duct system, and installation of new variable frequency drives and power circuits; modifications to AHU-1A & AHU-1B including new inverter-duty fan motors with variable frequency drives; installation of a new ductless-split air conditioning system in Mechanical Room 137 and other work indicated in the Contract Documents

Bids will be received for Single Prime only. All proposals shall be lump sum.

Pre-Bid Meeting

An open pre-bid meeting will be held for all interested bidders at 9:00 AM on July 27, 2023 at NCDA&CS Eaddy Bldg. - 4300 Reedy Creek Road – Raleigh, NC 27607. The meeting will address project specific questions, issues, bidding procedures and bid forms.

Complete plans, specifications and contract documents for this project in electronic format can be obtained from RMF Engineering during normal office hours after June 30, 2023. Email requests for electronic documents may be sent to kyle.pittman@rmf.com. Full printed copies may be obtained by those qualified as prime bidders, upon deposit of Two Hundred Dollars ($200) in cash or certified check with a minimum of 48 hours' notice to kyle.pittman@rmf.com. The full plan deposit will be returned to those bidders provided all documents are returned Bound, good, usuable condition within ten (10) days after the bid date.

Project documents are available for review through the online plan rooms of: Associated General Contractors, Carolinas Branch, in the online plan room of McGraw-Hill Dodge Corporation, and Reed Construction Data and in Minority Plan Rooms East Coast Digital (ECD) Plan Room Provider

Project documents will be submitted to NCIMED Plan & Resource Center, 114 West Parrish Street, 6th Floor, Durham, NC 27701, 919-956-8889 or 919-287-3036

Minority plan room information for Hispanic Contractors Association of the Carolinas (HCAC) in Winston-Salem, Charlotte and Raleigh Areas – 877-227-1680 will be verified prior to issuing documents.

NOTE: The bidder shall include with the bid proposal the form *Identification of Minority Business Participation* identifying the minority business participation it will use on the project and shall include either *Affidavit **A*** or *Affidavit **B*** as applicable. Forms and instructions are included within the Proposal Form in the bid documents. Failure to complete these forms is grounds for rejection of the bid. (GS143-128.2c Effective 1/1/2002.)

All contractors are hereby notified that they must have proper license as required under the state laws governing their respective trades.

General contractors are notified that Chapter 87, Article 1, General Statutes of North Carolina, will be observed in receiving and awarding general contracts. General contractors submitting bids on this project must have license classification for Unlimited Building.

> NOTE--SINGLE PRIME CONTRACTS: Under GS 87-1, a contractor that superintends or manages construction of any building, highway, public utility, grading, structure or improvement shall be deemed a "general contractor" and shall be so licensed. Therefore a single prime project that involves other trades will require the single prime contractor to hold a proper General Contractors license. **EXCEPT**: On public buildings being bid single prime, where the total value of the general construction does not exceed 25% of the total construction value, contractors under GS87- Arts 2 and 4 (Plumbing, Mechanical & Electrical) may bid and contract directly with the Owner as the SINGLE PRIME CONTRACTOR and may subcontract to other properly licensed trades. GS87-1.1- Rules .0210

Each proposal shall be accompanied by a cash deposit or a certified check drawn on some bank or trust company, insured by the Federal Deposit Insurance Corporation, of an amount equal to not less than five percent (5%) of the proposal, or in lieu thereof a bidder may offer a bid bond of five percent (5%) of the bid executed by a surety company licensed under the laws of North Carolina to execute the contract in accordance with the bid bond. Said deposit shall be retained by the owner as liquidated damages in event of failure of the successful bidder to execute the contract within ten days after the award or to give satisfactory surety as required by law.

A performance bond and a payment bond will be required for one hundred percent (100%) of the contract price.

Payment will be made based on ninety-five percent (95%) of monthly estimates and final payment made upon completion and acceptance of work.

No bid may be withdrawn after the scheduled closing time for the receipt of bids for a period of 30 days.

The owner reserves the right to reject any or all bids and to waive informalities.

Designer:
RMF Engineering, Inc.

8081 Arco Corporate Drive
Suite 300
Raleigh, NC 27617
Phone: (919) 941-9876
Kyle Pittman
kyle.pittman@rmf.com

Owner:
NC Department of Agriculture and Consumer Services
Property and Construction Division
1001 Mail Service Center

Raleigh, NC 27699-1001
Phone: (919) 707-3238
Andrew A. Meier
Andrew.meier@ncag

INSTRUCTIONS TO BIDDERS

AND

GENERAL CONDITIONS OF THE CONTRACT

STANDARD FORM FOR CONSTRUCTION PROJECTS

STATE CONSTRUCTION OFFICE

NORTH CAROLINA

DEPARTMENT OF ADMINISTRATION

Form OC-15

This document is intended for use on State capital construction projects and shall not be used on any project that is not reviewed and approved by the State Construction Office. Extensive modification to the General Conditions by means of "Supplementary General Conditions" is strongly discouraged. State agencies and institutions may include special requirements in "Division 1 – General Requirements" of the specifications, where they do not conflict with the General Conditions.

Twenty Fourth Edition January 2013

INSTRUCTIONS TO BIDDERS

For a proposal to be considered it must be in accordance with the following instructions:

1. **PROPOSALS**

Proposals must be made in strict accordance with the Form of Proposal provided therefor, and all blank spaces for bids, alternates, and unit prices applicable to bidder's work shall be properly filled in. When requested alternates are not bid, the proposer shall so indicate by the words "No Bid". Any blanks shall also be interpreted as "No Bid".The bidder agrees that bid on Form of Proposal detached from specifications will be considered and will have the same force and effect as if attached thereto. Photocopied or faxed proposals will not be considered. Numbers shall be stated both in writing and in figures for the base bids and alternates. If figures and writing differ, the written number will supersede the figures.

Any modifications to the Form of Proposal (including alternates and/or unit prices) will disqualify the bid and may cause the bid to be rejected.

The bidder shall fill in the Form of Proposal as follows:

a. If the documents are executed by a sole owner, that fact shall be evidenced by the word "Owner" appearing after the name of the person executing them.

b. If the documents are executed by a partnership, that fact shall be evidenced by the word "Co-Partner" appearing after the name of the partner executing them.

c. If the documents are executed on the part of a corporation, they shall be executed by either the president or the vice president and attested by the secretary or assistant secretary in either case, and the title of the office of such persons shall appear after their signatures. The seal of the corporation shall be impressed on each signature page of the documents.

d. If the proposal is made by a joint venture, it shall be executed by each member of the joint venture in the above form for sole owner, partnership or corporation, whichever form is applicable.

e. All signatures shall be properly witnessed.

f. If the contractor's license of a bidder is held by a person other than an owner, partner or officer of a firm, then the licensee shall also sign and be a party to the proposal. The title "Licensee" shall appear under his/her signature.

Proposals should be addressed as indicated in the Advertisement for Bids and be delivered, enclosed in an opaque sealed envelope, marked "Proposal" and bearing the title of the work, name of the bidder, and the contractor's license number of the bidder. Bidders should clearly mark on the outside of the bid envelope which contract(s) they are bidding.

Bidder shall identify on the bid**,** the minority businesses that will be utilized on the project with corresponding total dollar value of the bid and affidavit listing good faith efforts or an affidavit indicating work under contract will be self-performed, as required by G.S. 143-128.2(c) and G.S. 143-128.2(f). Failure to comply with these requirements is grounds for rejection of the bid.

For projects bid in the single-prime alternative, the names and license numbers of major subcontractors shall be listed on the proposal form.

It shall be the specific responsibility of the bidder to deliver his bid to the proper official at the selected place and prior to the announced time for the opening of bids. Later delivery of a bid for any reason, including delivery by any delivery service, shall disqualify the bid.

Unit prices quoted in the proposal shall include overhead and profit and shall be the full compensation for the contractor's cost involved in the work. See General Conditions, Article 19c-1.

2. EXAMINATION OF CONDITIONS

It is understood and mutually agreed that by submitting a bid the bidder acknowledges that he has carefully examined all documents pertaining to the work, the location, accessibility and general character of the site of the work and all existing buildings and structures within and adjacent to the site, and has satisfied himself as to the nature of the work, the condition of existing buildings and structures, the conformation of the ground, the character, quality and quantity of the material to be encountered, the character of the equipment, machinery, plant and any other facilities needed preliminary to and during prosecution of the work, the general and local conditions, the construction hazards, and all other matters, including, but not limited to, the labor situation which can in any way affect the work under the contract, and including all safety measures required by the Occupational Safety and Health Act of 1970 and all rules and regulations issued pursuant thereto. It is further mutually agreed that by submitting a proposal the bidder acknowledges that he has satisfied himself as to the feasibility and meaning of the plans, drawings, specifications and other contract documents for the construction of the work and that he accepts all the terms, conditions and stipulations contained therein; and that he is prepared to work in cooperation with other contractors performing work on the site.

Reference is made to contract documents for the identification of those surveys and investigation reports of subsurface or latent physical conditions at the site or otherwise affecting performance of the work which have been relied upon by the designer in preparing the documents. The owner will make copies of all such surveys and reports available to the bidder upon request.

Each bidder may, at his own expense, make such additional surveys and investigations as he may deem necessary to determine his bid price for the performance of the work. Any on-site investigation shall be done at the convenience of the owner. Any reasonable request for access to the site will be honored by the owner.

3. BULLETINS AND ADDENDA

Any addenda to specifications issued during the time of bidding are to be considered covered in the proposal and in closing a contract they will become a part thereof. It shall be the bidder’s responsibility to ascertain prior to bid time the addenda issued and to see that his bid includes any changes thereby required.

Should the bidder find discrepancies in, or omission from, the drawings or documents or should he be in doubt as to their meaning, he shall at once notify the designer who will send written instructions in the form of addenda to all bidders. Notification should be no later than seven (7) days prior to the date set for receipt of bids. Neither the owner nor the designer will be responsible for any oral instructions.

All addenda should be acknowledged by the bidder(s) on the Form of Proposal. However, even if not acknowledged, by submitting a bid, the bidder has certified that he has reviewed all issued addenda and has included all costs associated within his bid.

4. **BID SECURITY**

Each proposal shall be accompanied by a cash deposit or a certified check drawn on some bank or trust company insured by the Federal Deposit Insurance Corporation, or a bid bond in an amount equal to not less than five percent (5%) of the proposal, said deposit to be retained by the owner as liquidated damages in event of failure of the successful bidder to execute the contract within ten (10) days after the award or to give satisfactory surety as required by law (G.S. 143-129).

Bid bond shall be conditioned that the surety will, upon demand, forthwith make payment to the obligee upon said bond if the bidder fails to execute the contract. The owner may retain bid securities of any bidder(s) who may have a reasonable chance of award of contract for the full duration of time stated in the Notice to Bidders. Other bid securities may be released sooner, at the discretion of the owner. All bid securities (cash or certified checks) shall be returned to the bidders promptly after award of contracts, and no later then seven (7) days after expiration of the holding period stated in the Notice to Bidders. Standard Form of Bid Bond is included in these specifications and shall be used.

5. **RECEIPT OF BIDS**

Bids shall be received in strict accordance with requirements of the General Statutes of North Carolina. Bid security shall be required as prescribed by statute. Prior to the closing of the bid, the bidder will be permitted to change or withdraw his bid. Guidelines for opening of public construction bids are available from the State Construction Office.

6. **OPENING OF BIDS**

Upon opening, all bids shall be read aloud. Once bidding is closed, there shall not be any withdrawal of bids by any bidder and no bids may be returned by the designer to any bidder. After the opening of bids, no bid may be withdrawn, except under the provisions of General Statute 143-129.1, for a period of thirty days unless otherwise specified. Should the successful bidder default and fail to execute a contract, the contract may be awarded to the next lowest and responsible bidder. The owner reserves the unqualified right to reject any and all bids. Reasons for rejection may include, but shall not be limited to, the following:

a. If the Form of Proposal furnished to the bidder is not used or is altered.

b. If the bidder fails to insert a price for all bid items, alternate and unit prices requested.

c. If the bidder adds any provisions reserving the right to accept or reject any award.

d. If there are unauthorized additions or conditional bids, or irregularities of any kind which tend to make the proposal incomplete, indefinite or ambiguous as to its meaning.

e. If the bidder fails to complete the proposal form where information is requested so the bid may be properly evaluated by the owner.

f. If the unit prices contained in the bid schedule are unacceptable to the owner and the State Construction Office.

g. If the bidder fails to comply with other instructions stated herein.

7. **BID EVALUATION**

The award of the contract will be made to the lowest responsible bidder as soon as practical. The owner may award on the basis of the base bid and any alternates the owner chooses.

Before awarding a contract, the owner may require the apparent low bidder to qualify himself to be a responsible bidder by furnishing any or all of the following data:

a. The latest financial statement showing assets and liabilities of the company or other information satisfactory to the owner.

b. A listing of completed projects of similar size.

c. Permanent name and address of place of business.

d. The number of regular employees of the organization and length of time the organization has been in business under present name.

e. The name and home office address of the surety proposed and the name and address of the responsible local claim agent.

f. The names of members of the firms who hold appropriate trade licenses, together with license numbers.

g. If prequalified, contractor info will be reviewed and evaluated comparatively to submitted prequalification package.

Failure or refusal to furnish any of the above information, if requested, shall constitute a basis for disqualification of any bidder.

In determining the lowest responsible, responsive bidder, the owner shall take into consideration the bidder's compliance with the requirements of G.S. 143-128.2(c), the past performance of the bidder on construction contracts for the State with particular concern given to completion times, quality of work, cooperation with other contractors, and cooperation with the designer and owner. Failure of the low bidder to furnish affidavit and/or documentation as required by G.S. 143-128.2(c) shall constitute a basis for disqualification of the bid.

Should the owner adjudge that the apparent low bidder is not the lowest responsible, responsive bidder by virtue of the above information, said apparent low bidder will be so notified and his bid security shall be returned to him.

8. **PERFORMANCE BOND**

The successful bidder, upon award of contract, shall furnish a performance bond in an amount equal to 100 percent of the contract price. See Article 35, General Conditions.

9. **PAYMENT BOND**

The successful bidder, upon award of contract, shall furnish a payment bond in an amount equal to 100 percent of the contract price. See Article 35, General Conditions.

10. **PAYMENTS**

Payments to the successful bidders (contractors) will be made on the basis of monthly estimates. See Article 31, General Conditions.

11. **PRE-BID CONFERENCE**

Prior to the date set for receiving bids, the Designer may arrange and conduct a Pre-Bid Conference for all prospective bidders. The purpose of this conference is to review project requirements and to respond to questions from prospective bidders and their subcontractors or material suppliers related to the intent of bid documents. Attendance by prospective bidders shall be as required by the "Notice to Bidders".

12. **SUBSTITUTIONS**

In accordance with the provisions of G.S. 133-3, material, product, or equipment substitutions proposed by the bidders to those specified herein can only be considered during the bidding phase until ten (10) days prior to the receipt of bids when submitted to the Designer with sufficient data to confirm material, product, or equipment equality. Proposed substitutions submitted after this time will be considered only as potential change order.

Submittals for proposed substitutions shall include the following information:

a. Name, address, and telephone number of manufacturer and supplier as appropriate.

b. Trade name, model or catalog designation.

c. Product data including performance and test data, reference standards, and technical descriptions of material, product, or equipment. Include color samples and samples of available finishes as appropriate.

d. Detailed comparison with specified products including performance capabilities, warranties, and test results.

e. Other pertinent data including data requested by the Designer to confirm product equality.

If a proposed material, product, or equipment substitution is deemed equal by the Designer to those specified, all bidders of record will be notified by Addendum**.**

GENERAL CONDITIONS OF THE CONTRACT

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ARTICLE 1 - DEFINITIONS

a. The **contract documents** consist of the Notice to Bidders; Instructions to Bidders; General Conditions of the Contract; special conditions if applicable; Supplementary General Conditions; the drawing and specifications, including all bulletins, addenda or other modifications of the drawings and specifications incorporated into the documents prior to their execution; the proposal; the contract; the performance bond; the payment bond; insurance certificates; the approval of the attorney general; and the certificate of the Office of State Budget and Management. All of these items together form the contract.

b. The **owner** is the State of North Carolina through the agency named in the contract.

c. The **designer(s)** are those referred to within this contract, or their authorized representatives. The Designer(s), as referred to herein, shall mean architect and/or engineer. They will be referred to hereinafter as if each were of the singular number, masculine gender.

d. The **contractor**, as referred to hereinafter, shall be deemed to be either of the several contracting parties called the "Party of the First Part" in either of the several contracts in connection with the total project. Where, in special instances hereinafter, a particular contractor is intended, an adjective precedes the word "contractor," as "general," "heating," etc. For the purposes of a single prime contract, the term Contractor shall be deemed to be the single contracting entity identified as the “Party of the First Part” in the single Construction Contract. Any references or adjectives that name or infer multiple prime contractors shall be interpreted to mean the single prime Contractor.

e. A **subcontractor**, as the term is used herein, shall be understood to be one who has entered into a direct contract with a contractor, and includes one who furnishes materials worked to a special design in accordance with plans and specifications covered by the contract, but does not include one who only sells or furnishes materials not requiring work so described or detailed.

f. **Written notice** shall be defined as notice in writing delivered in person to the contractor, or to a partner of the firm in the case of a partnership, or to a member of the contracting organization, or to an officer of the organization in the case of a corporation, or sent to the last known business address of the contracting organization by registered mail.

g. **Work**, as used herein as a noun, is intended to include materials, labor, and workmanship of the appropriate contractor.

h. The **project** is the total construction work to be performed under the contract documents by the several contractors.

i. **Project Expediter,** as used herein, is an entity stated in the contract documents, designated to effectively facilitate scheduling and coordination of work activities. See Article 14(f) for responsibilities of a Project Expediter. **For the purposes of a single prime contract, the single prime contractor shall be designated as the Project Expediter.**

j. **Change order**, as used herein, shall mean a written order to the contractor subsequent to the signing of the contract authorizing a change in the contract. The change order shall be signed by the contractor, designer and the owner, and approved by the State Construction Office, in that order (Article 19).

k. **Field Order,** as used herein, shall mean a written approval for the contractor to proceed with the work requested by owner prior to issuance of a formal Change Order. The field order shall be signed by the contractor, designer, owner, and State Construction Office.

l. **Time of completion**, as stated in the contract documents, is to be interpreted as consecutive calendar days measured from the date established in the written Notice to Proceed, or such other date as may be established herein (Article 23).

m. **Liquidated damages,** as stated in the contract documents [, is an amount reasonably estimated in advance to cover the consequential damages associated with the Owner's economic loss in not being able to use the Project for its intended purposes at the end of the contract's completion date as amended by change order, if any, by reason of failure of the contractor(s) to complete the work within the time specified. Liquidated damages does not include the Owner's extended contract administration costs (including but not limited to additional fees for architectural and engineering services, testing services, inspection services, commissioning services, etc.), such other damages directly resulting from delays caused solely by the contractor, or consequential damages that the Owner identified in the bid documents that may be impacted by any delay caused soley by the Contractor (e.g., if a multi-phased project-subsequent phases, delays in start other projects that are dependent on the completion of this Project, extension of leases and/or maintenance agreements for other facilities).

n. **Surety**, as used herein, shall mean the bonding company or corporate body which is bound with and for the contractor, and which engages to be responsible for the contractor and his acceptable performance of the work.

o. **Routine written communications between the Designer and the Contractor** are any communication other than a "request for information" provided in letter, memo, or transmittal format, sent by mail, courier, electronic mail, or facsimile. Such communications can not be identified as "request for information".

p. **Clarification or Request for information (RFI)** is a request from the Contractor seeking an interpretation or clarification by the Designer relative to the contract documents. The RFI, which shall be labeled (RFI), shall clearly and concisely set forth the issue or item requiring clarification or interpretation and why the response is needed. The RFI must set forth the Contractor's interpretation or understanding of the contract documents requirements in question, along with reasons for such an understanding.

q. **Approval** means written or imprinted acknowledgement that materials, equipment or methods of construction are acceptable for use in the work**.**

r. **Inspection** shall mean examination or observation of work completed or in progress to determine its compliance with contract documents.

s. **"Equal to" or "approved equal"** shall mean materials, products, equipment, assemblies, or installation methods considered equal by the bidder in all characteristics (physical, functional, and aesthetic) to those specified in the contract documents. Acceptance of equal is subject to approval of Designer and owner.

t. **"Substitution" or "substitute"** shall mean materials, products, equipment, assemblies, or installation methods deviating in at least one characteristic (physical, functional, or aesthetic) from those specified, but which in the opinion of the bidder would improve competition and/or enhance the finished installation. Acceptance of substitution is subject to the approval of the Designer and owner.

u. **Provide** shall mean furnish and install complete in place, new, clean, operational, and ready for use.

v. **Indicated and shown** shall mean provide as detailed, or called for, and reasonably implied in the contract documents.

w. **Special inspector** is one who inspects materials, installation, fabrication, erection or placement of components and connections requiring special expertise to ensure compliance with the approved construction documents and referenced standards.

x. **Commissioning** is a quality assurance process that verifies and documents that building components and systems operate in accordance to the owner's project requirements and the project design documents.

y. **Designer Final Inspection** is the inspection performed by the design team to determine the completeness of the project in accordance with approved plans and specifications. This inspection occurs prior to SCO final inspection.

z. **SCO Final Inspection** is the inspection performed by the State Construction Office to determine the completeness of the project in accordance with NC Building Codes and approved plans and specifications.

aa. **Beneficial Occupancy** is requested by the owner and is occupancy or partial occupancy of the building after all life safety items have been completed as determined by the State Construction Office. Life safety items include but not limited to fire alarm, sprinkler, egress and exit lighting, fire rated walls, egress paths and security.

bb. Final Acceptance is the date in which the State Construction Office accepts the construction as totally complete. This includes the SCO Final Inspection and certification by the designer that all punch lists are completed.

ARTICLE 2 - INTENT AND EXECUTION OF DOCUMENTS

a. The drawings and specifications are complementary, one to the other, and that which is shown on the drawings or called for in the specifications shall be as binding as if it were both called for and shown. The intent of the drawings and specifications is to establish the scope of all labor, materials, transportation, equipment, and any and all other things necessary to provide a bid for a complete job. In case of discrepancy or disagreement in the contract documents, the order of precedence shall be: Form of Contract, specifications, large-scale detail drawings, small-scale drawings.

b. The wording of the specifications shall be interpreted in accordance with common usage of the language except that words having a commonly used technical or trade meaning shall be so interpreted in preference to other meanings.

c. The contractor shall execute each copy of the proposal, contract, performance bond and payment bond as follows:

1. If the documents are executed by a sole owner, that fact shall be evidenced by the word "Owner" appearing after the name of the person executing them.

2. If the documents are executed by a partnership, that fact shall be evidenced by the word "Co-Partner" appearing after the name of the partner executing them.

3. If the documents are executed on the part of a corporation, they shall be executed by either the president or the vice president and attested by the secretary or assistant secretary in either case, and the title of the office of such persons shall appear after their signatures. The seal of the corporation shall be impressed on each signature page of the documents.

4. If the documents are made by a joint venture, they shall be executed by each member of the joint venture in the above form for sole owner, partnership or corporation, whichever form is applicable to each particular member.

5. All signatures shall be properly witnessed.

6. If the contractor's license is held by a person other than an owner, partner or officer of a firm, then the licensee shall also sign and be a party to the contract. The title "Licensee" shall appear under his/her signature.

7. The bonds shall be executed by an attorney-in-fact. There shall be attached to each copy of the bond a certified copy of power of attorney properly executed and dated.

8. Each copy of the bonds shall be countersigned by an authorized individual agent of the bonding company licensed to do business in North Carolina. The title "Licensed Resident Agent" shall appear after the signature.

9. The seal of the bonding company shall be impressed on each signature page of the bonds.

10. The contractor's signature on the performance bond and the payment bond shall correspond with that on the contract. The date of performance and payment bond shall not be prior to the date of the contract.

ARTICLE 3 - CLARIFICATIONS AND DETAIL DRAWINGS

a. In such cases where the nature of the work requires clarification by the designer, such clarification shall be furnished by the designer with reasonable promptness by means of written instructions or detail drawings, or both. Clarifications and drawings shall be consistent with the intent of contract documents, and shall become a part thereof.

b. The contractor(s) and the designer shall prepare, if deemed necessary, a schedule fixing dates upon which foreseeable clarifications will be required. The schedule will be subject to addition or change in accordance with progress of the work. The designer shall furnish drawings or clarifications in accordance with that schedule. The contractor shall not proceed with the work without such detail drawings and/or written clarifications.

ARTICLE 4 - COPIES OF DRAWINGS AND SPECIFICATIONS

The designer or Owner shall furnish free of charge to the contractors electronic copies of plans and specifications. If requested by the contractor, paper copies of plans and specifications shall be furnished free of charge as follows:

a. General contractor - Up to twelve (12) sets of general contractor drawings and specifications, up to six (6) sets of which shall include drawings and specifications of all other contracts, plus a clean set of black line prints on white paper of all appropriate drawings, upon which the contractor shall clearly and legibly record all work-in-place that is at variance with the contract documents.

b. Each other contractor - Up to six (6) sets of the appropriate drawings and specifications, up to three (3) sets of which shall include drawings and specifications of all other contracts, plus a clean set of black line prints on white paper of all appropriate drawings, upon which the contractor shall clearly and legibly record all work-in-place that is at variance with the contract documents.

c. Additional sets shall be furnished at cost, including mailing, to the contractor upon request by the contractor. This cost shall be stated in the bidding documents.

d. For the purposes of a single-prime contract, the contractor shall receive up to 30 sets of drawings and specifications, plus a clean set of black line prints on white paper of all appropriate drawings, upon which the contractor shall clearly and legibly record all work-in-place that is at variance with the contract documents.

ARTICLE 5 - SHOP DRAWINGS, SUBMITTALS, SAMPLES, DATA

a. Within 15 consecutive calendar days after the notice to proceed, each prime contractor shall submit a schedule for submission of all shop drawings, product data, samples, and similar submittals through the Project Expediter to the Designer. This schedule shall indicate the items, relevant specification sections, other related submittal, data, and the date when these items will be furnished to the designer.

b. The Contractor(s) shall review, approve and submit to the Designer all Shop Drawings, Coordination Drawings, Product Data, Samples, Color Charts, and similar submittal data required or reasonably implied by the Contract Documents. Required Submittals shall bear the Contractor's stamp of approval, any exceptions to the Contract Documents shall be noted on the submittals, and copies of all submittals shall be of sufficient quantity for the Designer to retain up to three (3) copies of each submittal for his own use plus additional copies as may be required by the Contractor. Submittals shall be presented to the Designer in accordance with the schedule submitted in paragraph (a). so as to cause no delay in the activities of the Owner or of separate Contractors.

c. The Designer shall review required submittals promptly, noting desired corrections if any, and retaining three (3) copies (1 for the Designer, 1 for the owner and 1 for SCO) for his use. The remaining copies of each submittal shall be returned to the Contractor not later than twenty (20) days from the date of receipt by the Designer, for the Contractor's use or for corrections and resubmittal as noted by the Designer. When resubmittals are required, the submittal procedure shall be the same as for the original submittal**s.**

d. Approval of shop drawings/submittals by the Designer shall not be construed as relieving the Contractor from responsibility for compliance with the design or terms of the contract documents nor from responsibility of errors of any sort in the shop drawings, unless such lack of compliance or errors first have been called in writing to the attention of the Designer by the Contractor.

ARTICLE 6 - WORKING DRAWINGS AND SPECIFICATIONS AT THE JOB SITE

a. The contractor shall maintain, in readable condition at his job office, one complete set of working drawings and specifications for his work including all shop drawings. Such drawings and specifications shall be available for use by the designer, his authorized representative, owner or State Construction Office.

b. The contractor shall maintain at the job office, a day-to-day record of work-in-place that is at variance with the contract documents. Such variations shall be fully noted on project drawings by the contractor and submitted to the designer upon project completion and no later than 30 days after final acceptance of the project.

c. The contractor shall maintain at the job office a record of all required tests that have been performed, clearly indicating the scope of work inspected and the date of approval or rejection.

ARTICLE 7 - OWNERSHIP OF DRAWINGS AND SPECIFICATIONS

All drawings and specifications are instruments of service and remain the property of the owner. The use of these instruments on work other than this contract without permission of the owner is prohibited. All copies of drawings and specifications other than contract copies shall be returned to the owner upon request after completion of the work.

ARTICLE 8 - MATERIALS, EQUIPMENT, EMPLOYEES

a. The contractor shall, unless otherwise specified, supply and pay for all labor, transportation, materials, tools, apparatus, lights, power, heat, sanitary facilities, water, scaffolding and incidentals necessary for the completion of his work, and shall install, maintain and remove all equipment of the construction, other utensils or things, and be responsible for the safe, proper and lawful construction, maintenance and use of same, and shall construct in the best and most workmanlike manner, a complete job and everything incidental thereto, as shown on the plans, stated in the specifications, or reasonably implied therefrom, all in accordance with the contract documents.

b. All materials shall be new and of quality specified, except where reclaimed material is authorized herein and approved for use. Workmanship shall at all times be of a grade accepted as the best practice of the particular trade involved, and as stipulated in written standards of recognized organizations or institutes of the respective trades except as exceeded or qualified by the specifications.

c. Upon notice, the contractor shall furnish evidence as to quality of materials.

d. Products are generally specified by ASTM or other reference standard and/or by manufacturer's name and model number or trade name. When specified only by reference standard, the Contractor may select any product meeting this standard, by any manufacturer. When several products or manufacturers are specified as being equally acceptable, the Contractor has the option of using any product and manufacturer combination listed. However, the contractor shall be aware that the cited examples are used only to denote the quality standard of product desired and that they do not restrict bidders to a specific brand, make, manufacturer or specific name; that they are used only to set forth and convey to bidders the general style, type, character and quality of product desired; and that equivalent products will be acceptable. Request for substitution of materials, items, or equipment shall be submitted to the designer for approval or disapproval; such approval or disapproval shall be made by the designer prior to the opening of bids. Alternate materials may be requested after the award if it can clearly be demonstrated that it is an added benefit to the owner and the designer and owner approves.

e. The designer is the judge of equality for proposed substitution of products, materials or equipment.

g. If at any time during the construction and completion of the work covered by these contract documents, the language, conduct, or attire of any workman of the various crafts be adjudged a nuisance to the owner or designer, or if any workman be considered detrimental to the work, the contractor shall order such parties removed immediately from grounds.

ARTICLE 9 - ROYALTIES, LICENSES AND PATENTS

It is the intention of the contract documents that the work covered herein will not constitute in any way infringement of any patent whatsoever unless the fact of such patent is clearly evidenced herein. The contractor shall protect and save harmless the owner against suit on account of alleged or actual infringement. The contractor shall pay all royalties and/or license fees required on account of patented articles or processes, whether the patent rights are evidenced hereinafter.

ARTICLE 10 - PERMITS, INSPECTIONS, FEES, REGULATIONS

a. The contractor shall give all notices and comply with all laws, ordinances, codes, rules and regulations bearing on the conduct of the work under this contract. If the contractor observes that the drawings and specifications are at variance therewith, he shall promptly notify the designer in writing. See Instructions to Bidders, Paragraph 3, Bulletins and Addenda. Any necessary changes required after contract award shall be made by change order in accordance with Article 19. If the contractor performs any work knowing it to be contrary to such laws, ordinances, codes, rules and regulations, and without such notice to the designer, he shall bear all cost arising therefrom. Additional requirements implemented after bidding will be subject to equitable negotiations.

b. All work under this contract shall conform to the North Carolina State Building Code and other State, local and national codes as are applicable. The cost of all required inspections and permits shall be the responsibility of the contractor and included within the bid proposal. All water taps, meter barrels, vaults and impact fees shall be paid by the contractor unless otherwise noted.

d. Projects constructed by the State of North Carolina or by any agency or institution of the State are not subject to inspection by any county or municipal authorities and are not subject to county or municipal building codes. The contractor shall, however, cooperate with the county or municipal authorities by obtaining building permits. Permits shall be obtained at no cost.

e. Projects involving local funding (community colleges) are subject also to county and municipal building codes and inspection by local authorities. The contractor shall pay the cost of these permits and inspections.

ARTICLE 11 - PROTECTION OF WORK, PROPERTY AND THE PUBLIC

a. The contractors shall be jointly responsible for the entire site and the building or construction of the same and provide all the necessary protections, as required by the owner or designer, and by laws or ordinances governing such conditions. They shall be responsible for any damage to the owner's property, or of that of others on the job, by them, their personnel, or their subcontractors, and shall make good such damages. They shall be responsible for and pay for any damages caused to the owner. All contractors shall have access to the project at all times.

b. The contractor shall provide cover and protect all portions of the structure when the work is not in progress, provide and set all temporary roofs, covers for doorways, sash and windows, and all other materials necessary to protect all the work on the building, whether set by him, or any of the subcontractors. Any work damaged through the lack of proper protection or from any other cause, shall be repaired or replaced without extra cost to the owner.

c. No fires of any kind will be allowed inside or around the operations during the course of construction without special permission from the designer and owner.

d. The contractor shall protect all trees and shrubs designated to remain in the vicinity of the operations by building substantial boxes around same. He shall barricade all walks, roads, etc., as directed by the designer to keep the public away from the construction. All trenches, excavations or other hazards in the vicinity of the work shall be well barricaded and properly lighted at night.

e. The contractor shall provide all necessary safety measures for the protection of all persons on the job, including the requirements of the A.G.C. *Accident Prevention Manual in Construction*, as amended, and shall fully comply with all state laws or regulations and North Carolina State Building Code requirements to prevent accident or injury to persons on or about the location of the work. He shall clearly mark or post signs warning of hazards existing, and shall barricade excavations, elevator shafts, stairwells and similar hazards. He shall protect against damage or injury resulting from falling materials and he shall maintain all protective devices and signs throughout the progress of the work.

f. The contractor shall adhere to the rules, regulations and interpretations of the North Carolina Department of Labor relating to Occupational Safety and Health Standards for the Construction Industry (Title 29, Code of Federal Regulations, Part 1926, published in Volume 39, Number 122, Part II, June 24, 1974, *Federal Register*), and revisions thereto as adopted by General Statutes of North Carolina 95-126 through 155.

g. The contractor shall designate a responsible person of his organization as safety officer/inspector to inspect the project site for unsafe health and safety hazards, to report these hazards to the contractor for correction, and whose duties also include accident prevention on the project, and to provide other safety and health measures on the project site as required by the terms and conditions of the contract.The name of the safety inspector shall be made known to the designer and owner at the time of the preconstruction conference and in all cases prior to any work starting on the project.

h. In the event of emergency affecting the safety of life, the protection of work, or the safety of adjoining properties, the contractor is hereby authorized to act at his own discretion, without further authorization from anyone, to prevent such threatened injury or damage.

Any compensation claimed by the contractor on account of such action shall be determined as provided for under Article 19(b).

i. Any and all costs associated with correcting damage caused to adjacent properties of the construction site or staging area shall be borne by the contractor. These costs shall include but not be limited to flooding, mud, sand, stone, debris, and discharging of waste products.

ARTICLE 12 - SEDIMENTATION POLLUTION CONTROL ACT OF 1973

a. Any land-disturbing activity performed by the contractor(s) in connection with the project shall comply with all erosion control measures set forth in the contract documents and any additional measures which may be required in order to ensure that the project is in full compliance with the Sedimentation Pollution Control Act of 1973, as implemented by Title 15, North Carolina Administrative Code, Chapter 4, Sedimentation Control, Subchapters 4A, 4B and 4C, as amended (15 N.C.A.C. 4A, 4B and 4C).

b. Upon receipt of notice that a land-disturbing activity is in violation of said act, the contractor(s) shall be responsible for ensuring that all steps or actions necessary to bring the project in compliance with said act are promptly taken.

c. The contractor(s) shall be responsible for defending any legal actions instituted pursuant to N.C.G.S. 113A-64 against any party or persons described in this article.

d. To the fullest extent permitted by law, the contractor(s) shall indemnify and hold harmless the owner, the designer and the agents, consultants and employees of the owner and designer, from and against all claims, damages, civil penalties, losses and expenses, including, but not limited to, attorneys' fees, arising out of or resulting from the performance of work or failure of performance of work, provided that any such claim, damage, civil penalty, loss or expense is attributable to a violation of the Sedimentation Pollution Control Act. Such obligation shall not be construed to negate, abridge or otherwise reduced any other right or obligation of indemnity which would otherwise exist as to any party or persons described in this article.

ARTICLE 13 - INSPECTION OF THE WORK

a. It is a condition of this contract that the work shall be subject to inspection during normal working hours and during any time work is in preparation and progress by the designer, designated official representatives of the owner, State Construction Office and those persons required by state law to test special work for official approval. The contractor shall therefore provide safe access to the work at all times for such inspections.

b. All instructions to the contractor will be made only by or through the designer or his designated project representative. Observations made by official representatives of the owner shall be conveyed to the designer for review and coordination prior to issuance to the contractor.

c. All work shall be inspected by designer, special inspector and/or State Construction Office prior to being covered by the contractor. Contractor shall give a minimum two weeks notice unless otherwise agreed to by all parties. If inspection fails, after the first reinspection all costs associated with additional reinspections shall be borne by the contractor.

d. Where special inspection or testing is required by virtue of any state laws, instructions of the designer, specifications or codes, the contractor shall give adequate notice to the designer of the time set for such inspection or test, if the inspection or test will be conducted by a party other than the designer. Such special tests or inspections will be made in the presence of the designer, or his authorized representative, and it shall be the contractor's responsibility to serve ample notice of such tests.

e. All laboratory tests shall be paid by the owner unless provided otherwise in the contract documents except the general contractor shall pay for laboratory tests to establish design mix for concrete, and for additional tests to prove compliance with contract documents where materials have tested deficient except when the testing laboratory did not follow the appropriate ASTM testing procedures.

f. Should any work be covered up or concealed prior to inspection and approval by the designer, special inspector, and/or State Construction Office such work shall be uncovered or exposed for inspection, if so requested by the designer in writing. Inspection of the work will be made upon notice from the contractor. All cost involved in uncovering, repairing, replacing, recovering and restoring to design condition, the work that has been covered or concealed will be paid by the contractor involved.

ARTICLE 14 - CONSTRUCTION SUPERVISION AND SCHEDULE

a. Throughout the progress of the work, each contractor shall keep at the job site**,** a competent superintendent and supervisory staff satisfactory to the designer and the owner. The superintendent and supervisory staff shall not be changed without the consent of the designer and owner unless said superintendent ceases to be employed by the contractor or ceases to be competent as determined by the contractor, designer or owner. The superintendent and other staff designated by the contractor in writing shall have authority to act on behalf of the contractor, and instructions, directions or notices given to him shall be as binding as if given to the contractor. However, directions, instructions, and notices shall be confirmed in writing.

b. The contractor shall examine and study the drawings and specifications and fully understand the project design, and shall provide constant and efficient supervision to the work. Should he discover any discrepancies of any sort in the drawings or specifications, he shall report them to the designer without delay. He will not be held responsible for discrepancies in the drawings and/or specifications, but shall be held responsible to report them should they become known to him.

c. All contractors shall be required to cooperate and consult with each other during the construction of this project. Prior to installation of work, all contractors shall jointly prepare coordination drawings, showing locations of various ductworks, piping, motors, pumps, and other mechanical or electrical equipment, in relation to the structure, walls and ceilings. These drawings shall be submitted to the designer through the Project Expediter for information only**.** Each contractor shall lay out and execute his work to cause the least delay to other contractors. Each contractor shall be financially responsible for any damage to other contractor's work and for undue delay caused to other contractors on the project.

d. The contractor is required to attend job site progress conferences as called by the designer. The contractor shall be represented at these job progress conferences by both home office and project personnel. These representatives shall have authority to act on behalf of the contractor. These meetings shall be open to subcontractors, material

suppliers and any others who can contribute toward maintaining required job progress. It shall be the principal purpose of these meetings, or conferences, to effect coordination, cooperation and assistance in every practical way toward the end of maintaining progress of the project on schedule and to complete the project within the specified contract time. Each contractor shall be prepared to assess progress of the work as required in his particular contract and to recommend remedial measures for correction of progress as may be appropriate. The designer or his authorized representative shall be the coordinator of the conferences and shall preside as chairman. The contractor shall turn over a copy of his daily reports to the Designer and Owner at the job site progress conference. Owner will determine daily report format.

e The contractor(s) shall, employ an engineer or a land surveyor licensed in the State of North Carolina to lay out the work and to establish a bench mark in a location where same will not be disturbed and where direct instruments sights may be taken.

f. The designer shall designate a Project Expediter on projects involving two or more prime contracts. The Project Expediter shall be designated in the Supplementary General Conditions. The Project Expediter shall have at a minimum the following responsibilities**.**

1. Prepare the project construction schedule and shall allow all prime contractors (multi-prime contract) and subcontractors (single-prime contract) performing general, plumbing, HVAC, and electrical work equal input into the preparation of the initial construction schedule.

2. Maintain a project progress schedule for all contractors.

3. Give adequate notice to all contractors to ensure efficient continuity of all phases of the work.

4. Notify the designer of any changes in the project schedule.

5. Recommend to the owner whether payment to a contractor shall be approved**.**

g. It shall be the responsibility of the Project Expediter to cooperate with and obtain from several prime contractors and subcontractors on the job, their respective work activities and integrate these activities into a project construction schedule in form of a detailed bar chart or Critical Path Method (CPM), schedule. Each prime contractor shall provide work activities within fourteen (14) days of request by the Project Expediter. A "work activity", for scheduling purposes, shall be any component or contractual requirement of the project requiring at least one (1) day, but not more than fourteen (14) days, to complete or fulfill**.** The project construction schedule shall graphically show all salient features of the work required to construct the project from start to finish and within the allotted time established in the contract. The time (in days) between the contractor's early completion and contractual completion dates is part of the project total float time; and shall be used as such, unless amended by a change order**.** On a multi-prime project, each prime contractor shall review the proposed construction schedule and approve same in writing**.** The Project Expediter shall submit the proposed construction schedule to the designer for comments. The complete Project construction schedule shall be of the type set forth in the Supplementary General Condition or subparagraph (1) or (2) below, as appropriate:

1. For a project with total contracts of $500,000 or less, a bar chart schedule will satisfy the above requirement. The schedule shall indicate the estimated starting and completion dates for each major element of the work.

2. For a project with total contracts over $500,000, a Critical Path Method (CPM) schedule shall be utilized to control the planning and scheduling of the Work. The CPM schedule shall be the responsibility of the Project Expediter and shall be paid for by the Project Expediter.

Bar Chart Schedule: Where a bar chart schedule is required, it shall be time-scaled in weekly increments, shall indicate the estimated starting and completion dates for each major element of the work by trade and by area, level, or zone, and shall schedule dates for all salient features, including but not limited to the placing of orders for materials, submission of shop drawings and other Submittals for approval, approval of shop drawings by designers, the manufacture and delivery of material, the testing and the installation of materials, supplies and equipment, and all Work activities to be performed by the Contractor. The Contractor shall allow sufficient time in his schedule for all commissioning, required inspections and completion of final punchlist(s). Each Work activity will be assigned a time estimate by the Contractor. One day shall be the smallest time unit used.

CPM Schedule: Where a CPM schedule is required, it shall be in time-scaled precedence format using the Project Expediter's logic and time estimates. The CPM schedule shall be drawn or plotted with activities grouped or zoned by Work area or subcontract as opposed to a random (or scattered) format. The CPM schedule shall be time-scaled on a weekly basis and shall be drawn or plotted at a level of detail and logic which will schedule all salient features of the work to be performed by the Contractor. The Contractor shall allow sufficient time in his schedule for all commissioning, required inspections and completion of final punchlist(s).. Each Work activity will be assigned a time estimate by the Contractor. One day shall be the smallest time unit used.

The CPM schedule will identify and describe each activity, state the duration of each activity, the calendar dates for the early and late start and the early and late finish of each activity, and clearly highlight all activities on the critical path. "Total float" and "free float" shall be indicated for all activities. Float time shall not be considered for the exclusive use or benefit of either the Owner or the Contractor, but must be allocated in the best interest of completing the Work within the Contract time. Extensions to the Contract time, when granted by Change Order, will be granted only when equitable time adjustment exceeds the Total Float in the activity or path of activities affected by the change. On contracts with a price over $2,500,000, the CPM schedule shall also show what part of the Contract Price is attributable to each activity on the schedule, the sum of which for all activities shall equal the total Contract Price.

Early Completion of Project: The Contractor may attempt to complete the project prior to the Contract Completion Date. However, such planned early completion shall be for the Contractor's convenience only and shall not create any additional rights of the Contractor or obligations of the Owner under this Contract, nor shall it change the Time

for Completion or the Contract Completion Date. The Contractor shall not be required to pay liquidated damages to the Owner because of its failure to complete by its planned earlier date. Likewise, the Owner shall not pay the Contractor any additional compensation for early completion nor will the Owner owe the Contractor any compensation should the Owner, its officers, employees, or agents cause the Contractor not to complete earlier than the date required by the Contract Documents.

h. The proposed project construction schedule shall be presented to the designer no later than fifteen (15) days after written notice to proceed. No application for payment will be processed until this schedule is accepted by the designer and owner.

i. The approved project construction schedule shall be distributed to all contractors and displayed at the job site by the Project Expediter.

j. The several contractors shall be responsible for their work activities and shall notify the Project Expediter of any necessary changes or adjustments to their work. The Project Expediter shall maintain the project construction schedule, making biweekly adjustments, updates, corrections, etc., that are necessary to finish the project within the Contract time, keeping all contractors and the designer fully informed. Copy of a bar chart schedule annotated to show the current progress shall be submitted by the Contractor(s) to the designer, along with monthly request for payment. For project requiring CPM schedule, the Contractor shall submit a biweekly report of the status of all activities. The bar chart schedule or status report shall show the actual Work completed to date in comparison with the original Work scheduled for all activities. If any activities of the work of several contractors are behind schedule, the contractor must indicate in writing, what measures will be taken to bring each such activity back on schedule and to ensure that the Contract Completion Date is not exceeded. A plan of action and recovery schedule shall be developed and submitted to the designer by the Project Expediter, when (1) the contractor's report indicates delays, that are in the opinion of the designer or the owner, of sufficient magnitude that the contractor's ability to complete the work by the scheduled completion is brought into question; (2) the updated construction schedule is thirty (30) days behind the planned or baseline schedule and no legitimate time extensions, as determined by the Designer, are in process; and (3) the contractor desires to make changes in the logic (sequencing of work) or the planned duration of future activities of the CPM schedule which, in the opinion of the designer or the owner, are of a major nature. The plan of action, when required shall be submitted to the Owner for review within two (2) business days of the Contractor receiving the Owner's written demand. The recovery schedule, when required, shall be submitted to the Owner within five (5) calendar days of the Contractor's receiving the Owner's written demand. Failure to provide an updated construction schedule or a recovery schedule may be grounds for rejection of payment applications or withholding of funds as set forth in Article 33.

k. The Project Expediter shall notify each contractor of such events or time frames that are critical to the progress of the job. Such notice shall be timely and reasonable. Should the progress be delayed due to the work of any of the several contractors, it shall be the duty of the Project Expediter to immediately notify the contractor(s) responsible for such delay, the designer, the State Construction Office and other prime contractors. The designer shall determine the contractor(s) who caused the delays and notify the bonding company of the responsible contractor(s) of the delays; and shall make a recommendation to the owner regarding further action.

l. Designation as Project Expediter entails an additional project control responsibility and does not alter in any way the responsibility of the contractor so designated, nor the

responsibility of the other contractors involved in the project. The project expeditor's Superintendent(s) shall be in attendance at the Project site at all times when work is in progress unless conditions are beyond the control of the Contractor or until termination of the Contract in accordance with the Contract Documents. It is understood that such Superintendent shall be acceptable to the Owner and Designer and shall be the one who will be continued in that capacity for the duration of the project unless he ceases to be on the Contractor's payroll or the Owner otherwise agrees. The Superintendent shall not be employed on any other project for or by the Contractor or by any other entity during the course of the Work. If the Superintendent is employed by the Contractor on another project without the Owner's approval, then the Owner may deduct from the Contractor's monthly general condition costs and amount representing the Superintendent's cost and shall deduct that amount for each month thereafter until the Contractor has the Superintendent back on the Owner's Project full-time.

ARTICLE 15 - SEPARATE CONTRACTS AND CONTRACTOR RELATIONSHIPS

a. Effective from January 1, 2002, Chapter 143, Article 8, was amended, to allow public contracts to be delivered by the following delivery methods: single-prime, dual (single-prime and separate-prime), construction manager at risk, and alternative contracting method as approved by the State Building Commission. The owner reserves the right to prepare separate specifications, receive separate bids, and award separate contracts for such other major items of work as may be in the best interest of the State. For the purposes of a single prime contract, refer to Article 1 – Definitions.

b. All contractors shall cooperate with each other in the execution of their work, and shall plan their work in such manner as to avoid conflicting schedules or delay of the work. See Article 14, Construction Supervision.

c. If any part of contractor's work depends upon the work of another contractor, defects which may affect that work shall be reported to the designer in order that prompt inspection may be made and the defects corrected. Commencement of work by a contractor where such condition exists will constitute acceptance of the other contractor's work as being satisfactory in all respects to receive the work commenced, except as to defects which may later develop. The designer shall be the judge as to the quality of work and shall settle all disputes on the matter between contractors.

d. Any mechanical or electrical work such as sleeves, inserts, chases, openings, penetrations, etc., which is located in the work of the general contractor shall be built in by the general contractor. The respective mechanical and electrical contractors shall set all sleeves, inserts and other devices that are to be incorporated into the structure in cooperation and under the supervision of the general contractor. The responsibility for the exact location of such items shall be that of the mechanical and/or electrical contractor.

e. The designer and the owner shall have access to the work whenever it is in preparation and progress and during normal working hours. The contractor shall provide facilities for such access so the designer may perform his functions under the contract documents.

f. Should a contractor cause damage to the work or property of another contractor, he shall be directly responsible, and upon notice, shall promptly settle the claim or otherwise resolve the dispute.

ARTICLE 16 - SUBCONTRACTS AND SUBCONTRACTORS

a. Within thirty (30) days after award of the contract, the contractor shall submit to the designer, owner and to the State Construction Office a list giving the names and addresses of subcontractors and equipment and material suppliers he proposes to use, together with the scope of their respective parts of the work. Should any subcontractor be disapproved by the designer or owner, the designer or owner shall submit his reasons for disapproval in writing to the State Construction Office for its consideration with a copy to the contractor. If the State Construction Office concurs with the designer's or owner's recommendation, the contractor shall submit a substitute for approval. The designer and owner shall act promptly in the approval of subcontractors, and when approval of the list is given, no changes of subcontractors will be permitted except for cause or reason considered justifiable by the designer or owner.

b. The designer will furnish to any subcontractor, upon request, evidence regarding amounts of money paid to the contractor on account of the subcontractor's work.

c. The contractor is and remains fully responsible for his own acts or omissions as well as those of any subcontractor or of any employee of either. The contractor agrees that no contractual relationship exists between the subcontractor and the owner in regard to the contract, and that the subcontractor acts on this work as an agent or employee of the contractor.

d. The owner reserves the right to limit the amount of portions of work to be subcontracted as hereinafter specified.

ARTICLE 17 - CONTRACTOR AND SUBCONTRACTOR RELATIONSHIPS

The contractor agrees that the terms of these contract documents shall apply equally to each subcontractor as to the contractor, and the contractor agrees to take such action as may be necessary to bind each subcontractor to these terms. The contractor further agrees to conform to the Code of Ethical Conduct as adopted by the Associated General Contractors of America, Inc., with respect to contractor-subcontractor relationships, and that payments to subcontractors shall be made in accordance with the provisions of G.S. 143-134.1 titled Interest on final payments due to prime contractors: payments to subcontractors.

a. On all public construction contracts which are let by a board or governing body of the state government or any political subdivision thereof, except contracts let by the Department of Transportation pursuant to G.S. 136-28.1, the balance due prime contractors shall be paid in full within 45 days after respective prime contracts of the project have been accepted by the owner, certified by the architect, engineer or designer to be completed in accordance with terms of the plans and specifications, or occupied by the owner and used for the purpose for which the project was constructed, whichever occurs first. Provided, however, that whenever the architect or consulting engineer in charge of the project determines that delay in completion of the project in accordance with terms of the plans and specifications is the fault of the contractor, the project may be occupied and used for the purposes for which it was constructed without payment of any interest on amounts withheld past the 45 day limit. No payment shall be delayed because of the failure of another prime contractor on such project to complete his contract. Should final payment to any prime contractor beyond the date such contracts have been certified to be completed by the designer or architect, accepted by the owner, or occupied by the owner and used for the purposes for which the project was constructed, be delayed by more than 45 days, said prime contractor shall be paid interest, beginning on the 46th day, at the rate of one percent (1%) per month or fraction thereof unless a lower rate is

agreed upon on such unpaid balance as may be due. In addition to the above final payment provisions, periodic payments due a prime contractor during construction shall be paid in accordance with the payment provisions of the contract documents or said prime contractor shall be paid interest on any such unpaid amount at the rate stipulated above for delayed final payments. Such interest shall begin on the date the payment is due and continue until the date on which payment is made. Such due date may be established by the terms of the contract. Funds for payment of such interest on state-owned projects shall be obtained from the current budget of the owning department, institution or agency. Where a conditional acceptance of a contract exists, and where the owner is retaining a reasonable sum pending correction of such conditions, interest on such reasonable sum shall not apply.

b. Within seven days of receipt by the prime contractor of each periodic or final payment, the prime contractor shall pay the subcontractor based on work completed or service provided under the subcontract. Should any periodic or final payment to the subcontractor be delayed by more than seven days after receipt of periodic or final payment by the prime contractor, the prime contractor shall pay the subcontractor interest, beginning on the eighth day, at the rate of one percent (1%) per month or fraction thereof on such unpaid balance as may be due.

c. The percentage of retainage on payments made by the prime contractor to the subcontractor shall not exceed the percentage of retainage on payments made by the owner to the prime contractor. Any percentage of retainage on payments made by the prime contractor to the subcontractor that exceeds the percentage of retainage on payments made by the owner to the prime contractor shall be subject to interest to be paid by the prime contractor to the subcontractor at the rate of one percent (1%) per month or fraction thereof.

d. Nothing in this section shall prevent the prime contractor at the time of application and certification to the owner from withholding application and certification to the owner for payment to the subcontractor for unsatisfactory job progress; defective construction not remedied; disputed work; third-party claims filed or reasonable evidence that claim will be filed; failure of subcontractor to make timely payments for labor, equipment and materials; damage to prime contractor or another subcontractor; reasonable evidence that subcontract cannot be completed for the unpaid balance of the subcontract sum; or a reasonable amount for retainage not to exceed the initial percentage retained by owner.

ARTICLE 18 - DESIGNER'S STATUS

a. The designer shall provide general administration of the performance of construction contracts, including liaison and necessary inspection of the work to ensure compliance with plans and specifications. He is the agent of the owner only for the purpose of constructing this work and to the extent stipulated in the contract documents. He has authority to direct work to be performed, to stop work, to order work removed, or to order corrections of faulty work, where any such action by the designer may be necessary to assure successful completion of the work.

b. The designer is the impartial interpreter of the contract documents, and, as such, he shall exercise his powers under the contract to enforce faithful performance by both the owner and the contractor, taking sides with neither.

c. Should the designer cease to be employed on the work for any reason whatsoever, then the owner shall employ a competent replacement who shall assume the status of the former designer.

d. The designer and his consultants will make inspections of the project. He will inspect the progress, the quality and the quantity of the work.

e. The designer and the owner shall have access to the work whenever it is in preparation and progress during normal working hours. The contractor shall provide facilities for such access so the designer and owner may perform their functions under the contract documents.

f. Based on the designer's inspections and evaluations of the project, the designer shall issue interpretations, directives and decisions as may be necessary to administer the project. His decisions relating to artistic effect and technical matters shall be final, provided such decisions are within the limitations of the contract.

ARTICLE 19 - CHANGES IN THE WORK

a. The owner may have changes made in the work covered by the contract. These changes will not invalidate and will not relieve or release the contractor from any guarantee given by him pertinent to the contract provisions. These changes will not affect the validity of the guarantee bond and will not relieve the surety or sureties of said bond. All extra work shall be executed under conditions of the original contract.

b. Except in an emergency endangering life or property, no change shall be made by the contractor except upon receipt of approved change order or written field order from the designer, countersigned by the owner and the state construction office authorizing such change. No claim for adjustments of the contract price shall be valid unless this procedure is followed.

A field order, transmitted by fax, electronically, or hand delivered, may be used where the change involved impacts the critical path of the work. A formal change order shall be issued as expeditiously as possible.

In the event of emergency endangering life or property, the contractor may be directed to proceed on a time and material basis whereupon the contractor shall proceed and keep accurately on such form as specified by the designer or owner, a correct account of costs together with all proper invoices, payrolls and supporting data. Upon completion of the work the change order will be prepared as outlined under either Method "c(1)" or Method "c(2)" or both.

c. In determining the values of changes, either additive or deductive, contractors are restricted to the use of the following methods:

1. Where the extra work involved is covered by unit prices quoted in the proposal, or subsequently agreed to by the Contractor, Designer, Owner and State Construction Office the value of the change shall be computed by application of unit prices based on quantities, estimated or actual as agreed of the items involved, except is such cases where a quantity exceeds the estimated quantity allowance in the contract by one hundred percent (100%) or more. In such cases, either party may elect to proceed under subparagraph c2 herein. If neither party elects to proceed under c2, then unit prices shall apply.

2. The contracting parties shall negotiate and agree upon the equitable value of the change prior to issuance of the change order, and the change order shall stipulate the corresponding lump sum adjustment to the contract price.

d. Under Paragraph “b” and Methods "c(2)" above, the allowances for overhead and profit combined shall be as follows: all contractors (the single contracting entity (prime), his subcontractors(1st tier subs), or their sub-subcontractors (2nd tier subs, 3rd tier subs, etc)) shall be allowed a maximum of 10% on work they each self-perform; the prime contractor shall be allowed a maximum of 5% on contracted work of his 1st tier sub; 1st tier, 2nd tier, 3rd tier, etc contractors shall be allowed a maximum of 2.5% on the contracted workof their subs. ; Under Method "c(1)", no additional allowances shall be made for overhead and profit. In the case of deductible change orders, under Method "c(2)" and Paragraph (b) above, the contractor shall include no less than five percent (5%***)*** profit, but no allowances for overhead.

e. The term "net cost" as used herein shall mean the difference between all proper cost additions and deductions. The "cost" as used herein shall be limited to the following:

1. The actual costs of materials and supplies incorporated or consumed as part of the work;

2. The actual costs of labor expended on the project site; labor expended in coordination, change order negotiation, record document maintenance, shop drawing revision or other tasks necessary to the administration of the project are considered overhead whether they take place in an office or on the project site.

3. The actual costs of labor burden, limited to the costs of social security (FICA) and Medicare/Medicaid taxes; unemployment insurance costs; health/dental/vision insurance premiums; paid employee leave for holidays, vacation, sick leave, and/or petty leave, not to exceed a total of 30 days per year; retirement contributions; worker’s compensation insurance premiums; and the costs of general liability insurance when premiums are computed based on payroll amounts; the total of which shall not exceed thirty percent (30%) of the actual costs of labor;

4. The actual costs of rental for tools, excluding hand tools; equipment; machinery; and temporary facilities required for the work;

5. The actual costs of premiums for bonds, insurance, permit fees, and sales or use taxes related to the work.

Overtime and extra pay for holidays and weekends may be a cost item only to the extent approved by the owner.

f. Should concealed conditions be encountered in the performance of the work below grade, or should concealed or unknown conditions in an existing structure be at variance with the conditions indicated by the contract documents, the contract sum and time for completion may be equitably adjusted by change order upon claim by either party made within thirty (30) days after the condition has been identified. The cost of such change shall be arrived at by one of the foregoing methods. All change orders shall be supported by a unit cost breakdown showing method of arriving at net cost as defined above.

g. In all change orders, the procedure will be for the designer to request proposals for the change order work in writing. The contractor will provide such proposal and supporting data in suitable format. The designer shall verify correctness. Delay in the processing of the change order due to lack of proper submittal by the contractor of all required supporting data shall not constitute grounds for a time extension or basis of a claim. Within fourteen (14) days after receipt of the contractor’s accepted proposal including all supporting documentation required by the designer**,** the designer shall prepare the change order and forward to the contractor for his signature or otherwise respond, in writing, to

the contractor's proposal. Within seven (7) days after receipt of the change order executed by the contractor, the designer shall, certify the change order by his signature, and forward the change order and all supporting data to the owner for the owner's signature. The owner shall execute the change order and forward to the State Construction Office for final approval**,** within seven (7) days of receipt. The State Construction Office shall act on the change order within seven (7) days. In case of emergency or extenuating circumstances, approval of changes may be obtained verbally by telephone or field orders approved by all parties, then shall be substantiated in writing as outlined under normal procedure.

h. At the time of signing a change order, the contractor shall be required to certify as follows:

"I certify that my bonding company will be notified forthwith that my contract has been changed by the amount of this change order, and that a copy of the approved change order will be mailed upon receipt by me to my surety."

i. A change order, when issued, shall be full compensation, or credit, for the work included, omitted or substituted. It shall show on its face the adjustment in time for completion of the project as a result of the change in the work.

j. If, during the progress of the work, the owner requests a change order and the contractor's terms are unacceptable, the owner**,** with the approval of the State Construction Office, may require the contractor to perform such work on a time and material basis whereupon the contractor shall proceed and keep accurately on such form as specified by the Designer or owner, a correct account of cost together with all proper invoices, payrolls and supporting data. Upon completion of the work a change order will be prepared with allowances for overhead and profit per paragraph d. above and "net cost" and "cost" per paragraph e. above. Without prejudice, nothing in this paragraph shall preclude the owner from performing or to have performed that portion of the work requested in the change order.

ARTICLE 20 - CLAIMS FOR EXTRA COST

a. Should the contractor consider that as a result of instructions given by the designer, he is entitled to extra cost above that stated in the contract, he shall give written notice thereof to the designer within seven (7) days without delay. The written notice shall clearly state that a claim for extra cost is being made and shall provide a detailed justification for the extra cost. The contractor shall not proceed with the work affected until further advised, except in emergency involving the safety of life or property, which condition is covered in Article 19(b) and Article 11(h). No claims for extra compensation shall be considered unless the claim is so made. The designer shall render a written decision within seven (7) days of receipt of claim.

b. The contractor shall not act on instructions received by him from persons other than the designer, and any claims for extra compensation or extension of time on account of such instruction will not be honored. The designer shall not be responsible for misunderstandings claimed by the contractor of verbal instructions which have not been confirmed in writing, and in no case shall instructions be interpreted as permitting a departure from the contract documents unless such instruction is confirmed in writing and supported by a properly authorized change order.

c. Should a claim for extra compensation that complies with the requirements of (a) above by the contractor and is denied by the designer or owner, and cannot be resolved by a

representative of the State Construction Office, the contractor may request a mediation in connection with GS 143-128(f1) in the dispute resolution rules adopted by the State Building Commission (1 N.C.A.C. 30H .0101 through .1001). If the contractor is unable to resolve its claim as a result of mediation, the contractor may pursue the claim in accordance with the provisions of G.S. 143-135.3, or G.S. 143-135.6 where Community Colleges are the owner,and the following:

1. A contractor who has not completed a contract with a board for construction or repair work and who has not received the amount he claims is due under the contract may submit a verified written claim to the director of the State Construction Office of the Department of Administration for the amount the contractor claims is due. The director may deny, allow or compromise the claim, in whole or in part. A claim under this subsection is not a contested case under Chapter 150B of the General Statutes.

2. (a) A contractor who has completed a contract with a board for construction or repair work and who has not received the amount he claims is due under the contract may submit a verified written claim to the director of the State Construction Office of the Department of Administration for the amount the contractor claims is due. The claim shall be submitted within sixty (60) days after the contractor receives a final statement of the board's disposition of his claim and shall state the factual basis for the claim.

   (b) The director shall investigate a submitted claim within ninety (90) days of receiving the claim, or within any longer time period upon which the director and the contractor agree. The contractor may appear before the director, either in person or through counsel, to present facts and arguments in support of his claim. The director may allow, deny or compromise the claim, in whole or in part. The director shall give the contractor a written statement of the director's decision on the contractor's claim.

   (c) A contractor who is dissatisfied with the director's decision on a claim submitted under this subsection may commence a contested case on the claim under Chapter 150B of the General Statutes. The contested case shall be commenced within sixty (60) days of receiving the director's written statement of the decision.

   (d) As to any portion of a claim that is denied by the director, the contractor may, in lieu of the procedures set forth in the preceding subsection of this section, within six (6) months of receipt of the director's final decision, institute a civil action for the sum he claims to be entitled to under the contract by filing a verified complaint and the issuance of a summons in the Superior Court of Wake County or in the superior court of any county where the work under the contract was performed. The procedure shall be the same as in all civil actions except that all issues shall be tried by the judge, without a jury.

ARTICLE 21 - MINOR CHANGES IN THE WORK

The designer will have the authority to order minor changes in the work not involving an adjustment in the contract sum or time for completion, and not inconsistent with the intent of the contract documents. Such changes shall be effected by written order, copied to the State Construction Office, and shall be binding on the owner and the contractor.

ARTICLE 22 - UNCORRECTED FAULTY WORK

Should the correction of faulty or damaged work be considered inadvisable or inexpedient by the owner and the designer, the owner shall be reimbursed by the contractor. A change order will be issued to reflect a reduction in the contract sum.

ARTICLE 23 - TIME OF COMPLETION, DELAYS, EXTENSION OF TIME

a. The time of completion is stated in the Supplementary General Conditions and in the Form of Construction Contract. The Project Expediter, upon notice of award of contract, shall prepare a construction schedule to complete the project within the time of completion as required by Article 14.

b. The contractors shall commence work to be performed under this agreement on a date to be specified in a written Notice to Proceed from the designer and shall fully complete all work hereunder within the time of completion stated. Time is of the essence and the contractor acknowledges the Owner will likely suffer financial damage for failure to complete the work within the time of completion. For each day in excess of the above number of days, the contractor(s) shall pay the owner the sum stated as liquidated damages reasonably estimated in advance to cover the losses to be incurred by the owner by reason of failure of said contractor(s) to complete the work within the time specified, such time being in the essence of this contract and a material consideration thereof.

c. In the event of multiple prime contractors, the designer shall be the judge as to the division of responsibility between the contractor(s), based on the construction schedule, weekly reports and job records, and shall apportion the amount of liquidated damages to be paid by each of them, according to delay caused by any or all of them.

d. If the contractor is delayed at any time in the progress of his work solely by any act or negligence of the owner, the designer, or by any employee of either; by any separate contractor employed by the owner; by changes ordered in the work; by labor disputes at the project site; by abnormal weather conditions not reasonably anticipated for the locality where the work is performed; by unavoidable casualties; by any causes beyond the contractor's control; or by any other causes which the designer and owner determine may justify the delay, then the contract time may be extended by change order only for the time which the designer and owner may determine is reasonable.

   Time extensions will not be granted for rain, wind, snow or other natural phenomena of normal intensity for the locality where work is performed. For purpose of determining extent of delay attributable to unusual weather phenomena, a determination shall be made by comparing the weather for the contract period involved with the average of the preceding five (5) year climatic range during the same time interval based on the National Oceanic and Atmospheric Administration National Weather Service statistics for the locality where work is performed and on daily weather logs kept on the job site by the contractor reflecting the effect of the weather on progress of the work and initialed by the designer's representative. No weather delays shall be considered after the building is dried in unless work claimed to be delayed is on the critical path of the baseline schedule or approved updated schedule. Time extensions for weather delays, acts of God, labor disputes, fire, delays in transportation, unavoidable casualties or other delays which are beyond the control of the Owner do not entitle the Contractor to compensable damages for delays. Any contractor claim for compensable damages for delays is limited to delays caused solely by the owner or its agents. Contractor caused delays shall be accounted for before owner or designer caused delays in the case of concurrent delays.

e. Request for extension of time shall be made in writing to the designer, copies to the owner and SCO, within twenty (20) days following cause of delay. In case of continuing cause for delay, the Contractor shall notify the_Designer to the designer, copies to the owner and SCO, of the delay within 20 days of the beginning of the delay and only one claim is necessary.

f. The contractor shall notify his surety in writing of extension of time granted.

g. No claim for time extension shall be allowed on account of failure of the designer to furnish drawings or instructions until twenty (20) days after demand for such drawings and/or instructions. See Article 5c. Demand must be in written form clearly stating the potential for delay unless the drawings or instructions are provided. Any delay granted will begin after the twenty (20) day demand period is concluded.

ARTICLE 24 - PARTIAL UTILIZATION/BENEFICIAL OCCUPANCY

a. The owner may desire to occupy or utilize all or a portion of the project prior to the completion of the project.

b. Should the owner request a utilization of a building or portion thereof, the designer shall perform a designer final inspection of area after being notified by the contractor that the area is ready for such. After the contractor has completed designer final inspection punch list and the designer has verified, then the designer shall schedule a beneficial occupancy inspection at a time and date acceptable to the owner, contractor(s) and State Construction Office. If beneficial occupancy is granted by the State Construction Office, in such areas the following will be established:

1. The beginning of guarantees and warranties period for the equipment necessary to support. in the area.

2. The owner assumes all responsibiliites for utility costs for entire building.

2. Contractor will obtain consent of surety.

3. Contractor will obtain endorsement from insurance company permitting beneficial occupancy.

c. The owner shall have the right to exclude the contractor from any part of the project which the designer has so certified to be substantially complete, but the owner will allow the contractor reasonable access to complete or correct work to bring it into compliance with the contract.

d. Occupancy by the owner under this article will in no way relieve the contractor from his contractual requirement to complete the project within the specified time. The contractor will not be relieved of liquidated damages because of beneficial occupancy. The designer may prorate liquidated damages based on the percentage of project occupied.

ARTICLE 25 - FINAL INSPECTION, ACCEPTANCE, AND PROJECT CLOSEOUT

a. Upon notification from the contractor(s) that the project is complete and ready for inspection, the designer shall make a Designer final inspection to verify that the project is complete and ready for SCO final inspection. Prior to SCO final inspection, the contractor(s) shall complete all items requiring corrective measures noted at the Designer

final inspection**.** The designer shall schedule a SCO final inspection at a time and date acceptable to the owner, contractor(s) and State Construction Office.

b. At the SCO final inspection, the designer and his consultants shall, if job conditions warrant, record a list of items that are found to be incomplete or not in accordance with the contract documents. At the conclusion of the SCO final inspection, the designer and State Construction Office representative shall make one of the following determinations:

   1. That the project is completed and accepted.

   2. That the project will be accepted subject to the correction of the list of discrepancies (punch list). All punch list items must be completed within thirty (30) days of SCO final inspection or the owner may invoke Article 28, Owner's Right to Do Work.

   4. That the project is not complete and another date for a SCO final inspection will be established.

c. Within fourteen (14) days of final acceptance per Paragraph b1 or within fourteen (14) days after completion of punch list per Paragraph b2 above, the designer shall certify the work and issue applicable certificate(s) of compliance.

d. Any discrepancies listed or discovered after the date of SCO final inspection and acceptance under Paragraphs b1 or b2 above shall be handled in accordance with Article 42, Guarantee.

f. The final acceptance date will establish the following:

   1. The beginning of guarantees and warranties period.

   2. The date on which the contractor's insurance coverage for public liability, property damage and builder's risk may be terminated.

   3. That no liquidated damages (if applicable) shall be assessed after this date.

   4. The termination date of utility cost to the contractor.

g. Prior to issuance of final acceptance date, the contractor shall have his authorized representatives visit the project and give full instructions to the designated personnel regarding operating, maintenance, care, and adjustment of all equipment and special construction elements. In addition, the contractor shall provide to the owner a complete instructional video (media format acceptable to the owner) on the operation, maintenance, care and adjustment of all equipment and special construction elements.

ARTICLE 26 - CORRECTION OF WORK BEFORE FINAL PAYMENT

a. Any work, materials, fabricated items or other parts of the work which have been condemned or declared not in accordance with the contract by the designer shall be promptly removed from the work site by the contractor, and shall be immediately replaced by new work in accordance with the contract at no additional cost to the owner. Work or property of other contractors or the owner, damaged or destroyed by virtue of such faulty work, shall be made good at the expense of the contractor whose work is faulty.

b. Correction of condemned work described above shall commence within twenty-four (24) hours after receipt of notice from the designer, and shall make satisfactory progress, as determined by the designer, until completed.

c. Should the contractor fail to proceed with the required corrections, then the owner may complete the work in accordance with the provisions of Article 28.

ARTICLE 27 - CORRECTION OF WORK AFTER FINAL PAYMENT

See Article 35, Performance Bond and Payment Bond, and Article 42, Guarantee**.** Neither the final certificate, final payment, occupancy of the premises by the owner, nor any provision of the contract, nor any other act or instrument of the owner, nor the designer, shall relieve the contractor from responsibility for negligence, or faulty material or workmanship, or failure to comply with the drawings and specifications. Contractor shall correct or make good any defects due thereto and repair any damage resulting there from, which may appear during the guarantee period following final acceptance of the work except as stated otherwise under Article 42, Guarantee. The owner will report any defects as they may appear to the contractor and establish a time limit for completion of corrections by the contractor. The owner will be the judge as to the responsibility for correction of defects.

ARTICLE 28 - OWNER'S RIGHT TO DO WORK

If, during the progress of the work or during the period of guarantee, the contractor fails to prosecute the work properly or to perform any provision of the contract, the owner, after seven (7) days' written notice sent by certified mail, return receipt requested, to the contractor from the designer, may perform or have performed that portion of the work. The cost of the work may be deducted from any amounts due or to become due to the contractor, such action and cost of same having been first approved by the designer. Should the cost of such action of the owner exceed the amount due or to become due the contractor, then the contractor or his surety, or both, shall be liable for and shall pay to the owner the amount of said excess.

ARTICLE 29 - ANNULMENT OF CONTRACT

If the contractor fails to begin the work under the contract within the time specified, or the progress of the work is not maintained on schedule, or the work is not completed within the time above specified, or fails to perform the work with sufficient workmen and equipment or with sufficient materials to ensure the prompt completion of said work, or shall perform the work unsuitably or shall discontinue the prosecution of the work, or if the contractor shall become insolvent or be declared bankrupt or commit any act of bankruptcy or insolvency, or allow any final judgment to stand against him unsatisfied for a period of forty-eight (48) hours, or shall make an assignment for the benefit of creditors, or for any other cause whatsoever shall not carry on the work in an acceptable manner, the owner may give notice in writing, sent by certified mail, return receipt requested, to the contractor and his surety of such delay, neglect or default, specifying the same, and if the contractor within a period of seven (7) days after such notice shall not proceed in accordance therewith, then the owner shall, declare this contract in default, and, thereupon, the surety shall promptly take over the work and complete the performance of this contract in the manner and within the time frame specified. In the event the surety shall fail to take over the work to be done under this contract within seven (7) days after being so notified and notify the owner in writing, sent by certified mail, return receipt requested, that he is taking the same over and stating that he will diligently pursue and complete the same, the owner shall have full power and authority, without violating the contract, to take the prosecution of the work out of the hands of said contractor, to appropriate or use any or all contract materials and equipment on the grounds as may be suitable and acceptable and may enter into an agreement, either by public letting or negotiation, for the completion of said contract according to the terms and provisions thereof

or use such other methods as in his opinion shall be required for the completion of said contract in an acceptable manner. All costs and charges incurred by the owner, together with the costs of completing the work under contract, shall be deducted from any monies due or which may become due said contractor and surety. In case the expense so incurred by the owner shall be less than the sum which would have been payable under the contract, if it had been completed by said contractor, then the said contractor and surety shall be entitled to receive the difference, but in case such expense shall exceed the sum which would have been payable under the contract, then the contractor and the surety shall be liable and shall pay to the owner the amount of said excess.

ARTICLE 30 - CONTRACTOR'S RIGHT TO STOP WORK OR TERMINATE THE CONTRACT

a. Should the work be stopped by order of a court having jurisdiction, or by order of any other public authority for a period of three months, due to cause beyond the fault or control of the contractor, or if the owner should fail or refuse to make payment on account of a certificate issued by the designer within forty-five (45) days after receipt of same, then the contractor, after fifteen (15) days' written notice sent by certified mail, return receipt requested, to the owner and the designer, may suspend operations on the work or terminate the contract.

b. The owner shall be liable to the contractor for the cost of all materials delivered and work performed on this contract plus 10 percent overhead and profit and shall make such payment. The designer shall be the judge as to the correctness of such payment.

ARTICLE 31 - REQUEST FOR PAYMENT

a. Not later than the fifth day of the month, the contractor shall submit to the designer a request for payment for work done during the previous month. The request shall be in the form agreed upon between the contractor and the designer, but shall show substantially the value of work done and materials delivered to the site during the period since the last payment, and shall sum up the financial status of the contract with the following information:

    1. Total of contract including change orders.

    2. Value of work completed to date.

    3. Less five percent (5%) retainage, provided however, that after fifty percent (50%) of the contractor’s work has been satisfactorily completed on schedule, with approval of the owner and the State Construction Office and written consent of the surety, further requirements for retainage will be waived only so long as work continues to be completed satisfactorily and on schedule.

    4. Less previous payments.

    5. Current amount due.

b. The contractor, upon request of the designer, shall substantiate the request with invoices of vouchers or payrolls or other evidence.

c. Prior to submitting the first request, the contractor shall prepare for the designer a schedule showing a breakdown of the contract price into values of the various parts of the work, so arranged as to facilitate payments to subcontractors in accordance with Article 17, Contractor and Subcontractor Relationships. The contractor(s) shall list the

value of each subcontractor and supplier, identifying each minority business subcontractor and supplier as listed in Affidavit C, if applicable.

d. When payment is made on account of stored materials and equipment, such materials must be stored on the owner's property, and the requests for payments shall be accompanied by invoices or bills of sale or other evidence to establish the owner's title to such materials and equipment. Such payments will be made only for materials that have been customized or fabricated specifically for this project. Raw materials or commodity products including but not limited to piping, conduit, CMU, metal studs and gypsum board may not be submitted. Responsibility for such stored materials and equipment shall remain with the contractor regardless of ownership title. Such stored materials and equipment shall not be removed from the owner's property. Should the space for storage on-site be limited, the contractor, at his option, shall be permitted to store such materials and/or equipment in a suitable space off-site. Should the contractor desire to include any such materials or equipment in his application for payment, they must be stored in the name of the owner in an independent, licensed, bonded warehouse approved by the designer, owner and the State Construction Office and located as close to the site as possible. The warehouse selected must be approved by the contractor's bonding and insurance companies; the material to be paid for shall be assigned to the owner and shall be inspected by the designer. Upon approval by the designer, owner and SCO of the storage facilities and materials and equipment, payment therefore will be certified. Responsibility for such stored materials and equipment shall remain with the contractor. Such stored materials and equipment shall not be moved except for transportation to the project site. Under certain conditions, the designer may approve storage of materials at the point of manufacture, which conditions shall be approved by the designer, the owner and the State Construction Office prior to approval for the storage and shall include an agreement by the storing party which unconditionally gives the State absolute right to possession of the materials at anytime. Bond, security and insurance protection shall continue to be the responsibility of the contractor(s).

e. In the event of beneficial occupancy, retainage of funds due the contractor(s) may be reduced with the approval of the State Construction Office to an equitable amount to cover the list of items to be completed or corrected. Retainage may not be reduced to less than two and one-half (2 1/2) times the estimated value of the work to be completed or corrected. Reduction of retainage must be with the consent and approval of the contractor's bonding company.

ARTICLE 32 - CERTIFICATES OF PAYMENT AND FINAL PAYMENT

a. Within five (5) days from receipt of request for payment from the contractor, the designer shall issue and forward to the owner a certificate for payment. This certificate shall indicate the amount requested or as approved by the designer. If the certificate is not approved by the designer, he shall state in writing to the contractor and the owner his reasons for withholding payment.

b. No certificate issued or payment made shall constitute an acceptance of the work or any part thereof. The making and acceptance of final payment shall constitute a waiver of all claims by the owner except:

   1. Claims arising from unsettled liens or claims against the contractor.

   2. Faulty work or materials appearing after final payment.

   3. Failure of the contractor to perform the work in accordance with drawings and specifications, such failure appearing after payment.

4. As conditioned in the performance bond and payment bond.

c. The making and acceptance of final payment shall constitute a waiver of all claims by the contractor except those claims previously made and remaining unsettled (Article 20(c)).

d. Prior to submitting request for final payment to the designer for approval, the contractor shall fully comply with all requirements specified in the" project closeout" section of the specifications. These requirements include but not limited to the following:

1. Submittal of Product and Operating Manuals, Warranties and Bonds, Guarantees, Maintenance Agreements, As-Built Drawings, Certificates of Inspection or Approval from agencies having jurisdiction. (The designer must approve the Manuals prior to delivery to the owner).

2. Transfer of Required attic stock material and all keys in an organized manner.

3. Record of Owner's training.

4. Resolution of any final inspection discrepancies.

5. Granting access to Contractor's records, if Owner's internal auditors have made a request for such access pursuant to Article 52.

e. The contractor shall forward to the designer, the final application for payment along with the following documents:

1. List of minority business subcontractors and material suppliers showing breakdown of contract amounts and total actual payments to subs and material suppliers.

2. Affidavit of Release of Liens.

3. Affidavit of contractors of payment to material suppliers and subcontractors. (See Article 36).

4. Consent of Surety to Final Payment**.**

5. Certificates of state agencies required by state law.

f. The designer will not authorize final payment until the work under contract has been certified by designer, certificates of compliance issued, and the contractor has complied with the closeout requirements. The designer shall forward the contractor's final application for payment to the owner along with respective certificate(s) of compliance required by law.

ARTICLE 33 - PAYMENTS WITHHELD

a. The designer with the approval of the State Construction Office may withhold payment for the following reasons:

1. Faulty work not corrected.

2. The unpaid balance on the contract is insufficient to complete the work in the judgment of the designer.

3. To provide for sufficient contract balance to cover liquidated damages that will be assessed.

b. The secretary of the Department of Administration may authorize the withholding of payment for the following reasons:

1. Claims filed against the contractor or evidence that a claim will be filed.

2. Evidence that subcontractors have not been paid.

c. The Owner may withhold all or a portion of Contractor's general conditions costs set forth in the approved schedule of values, if Contractor has failed to comply with: (1) a request to access its records by Owner's internal auditors pursuant to Article 52; (2) a request for a plan of action and/or recovery schedule under Article 14.j or provide The Owner; (3) a request to provide an electronic copies of Contractor's baseline schedule, updates with all logic used to create the schedules in the original format of the scheduling software; and (4) Contractor's failure to have its Superintendent on the Project full-time; (

d. When grounds for withholding payments have been removed, payment will be released. Delay of payment due the contractor without cause will make owner liable for payment of interest to the contractor in accordance with G.S. 143-134.1. As provided in G.S.143-134.1(e) the owner shall not be liable for interest on payments withheld by the owner for unsatisfactory job progess, defective construction not remedied, disputed work, or third-party claims filed against the owner or reasonable evidence that a third-party claim will be filed.

ARTICLE 34 - MINIMUM INSURANCE REQUIREMENTS

The work under this contract shall not commence until the contractor has obtained all required insurance and verifying certificates of insurance have been approved in writing by the owner. These certificates shall document that coverages afforded under the policies will not be cancelled, reduced in amount or coverages eliminated until at least thirty (30) days after mailing written notice, by certified mail, return receipt requested, to the insured and the owner of such alteration or cancellation. If endorsements are needed to comply with the notification or other requirements of this article copies of the endorsements shall be submitted with the certificates.

a. **Worker's Compensation and Employer's Liability**

The contractor shall provide and maintain, until final acceptance, workmen's compensation insurance, as required by law, as well as employer's liability coverage with minimum limits of $100,000.

b. **Public Liability and Property Damage**

The contractor shall provide and maintain, until final acceptance, comprehensive general liability insurance, including coverage for premises operations, independent contractors, completed operations, products and contractual exposures, as shall protect such contractors from claims arising out of any bodily injury, including accidental death, as well as from claims for property damages which may arise from operations under this contract, whether such operations be by the contractor or by any subcontractor, or by

anyone directly or indirectly employed by either of them and the minimum limits of such insurance shall be as follows:

Bodily Injury:	$500,000 per occurrence
Property Damage:	$100,000 per occurrence / $300,000 aggregate

In lieu of limits listed above, a $500,000 combined single limit shall satisfy both conditions.

Such coverage for completed operations must be maintained for at least two (2) years following final acceptance of the work performed under the contract.

c. **Property Insurance (Builder's Risk/Installation Floater)**

The contractor shall purchase and maintain property insurance until final acceptance, upon the entire work at the site to the full insurable value thereof. This insurance shall include the interests of the owner, the contractor, the subcontractors and sub-subcontractors in the work and shall insure against the perils of fire, wind, rain, flood, extended coverage, and vandalism and malicious mischief. If the owner is damaged by failure of the contractor to purchase or maintain such insurance, then the contractor shall bear all reasonable costs properly attributable thereto; the contractor shall effect and maintain similar property insurance on portions of the work stored off the site when request for payment per articles so includes such portions.

d. **Deductible**

Any deductible, if applicable to loss covered by insurance provided, is to be borne by the contractor.

e. **Other Insurance**

The contractor shall obtain such additional insurance as may be required by the owner or by the General Statutes of North Carolina including motor vehicle insurance, in amounts not less than the statutory limits.

f. **Proof of Carriage**

The contractor shall furnish the owner with satisfactory proof of carriage of the insurance required before written approval is granted by the owner.

ARTICLE 35 - PERFORMANCE BOND AND PAYMENT BOND

a. Each contractor shall furnish a performance bond and payment bond executed by a surety company authorized to do business in North Carolina. The bonds shall be in the full contract amount. Bonds shall be executed in the form bound with these specifications.

b. All bonds shall be countersigned by an authorized agent of the bonding company who is licensed to do business in North Carolina.

ARTICLE 36 - CONTRACTOR'S AFFIDAVIT

The final payment of retained amount due the contractor on account of the contract shall not become due until the contractor has furnished to the owner through the designer an affidavit signed, sworn and notarized to the effect that all payments for materials, services or subcontracted work in connection with his contract have been satisfied, and that no claims or

liens exist against the contractor in connection with this contract. In the event that the contractor cannot obtain similar affidavits from subcontractors to protect the contractor and the owner from possible liens or claims against the subcontractor, the contractor shall state in his affidavit that no claims or liens exist against any subcontractor to the best of his (the contractor's) knowledge, and if any appear afterward, the contractor shall save the owner harmless.

ARTICLE 37 - ASSIGNMENTS

The contractor shall not assign any portion of this contract nor subcontract in its entirety. Except as may be required under terms of the performance bond or payment bond, no funds or sums of money due or become due the contractor under the contract may be assigned.

ARTICLE 38 - USE OF PREMISES

a. The contractor(s) shall confine his apparatus, the storage of materials and the operations of his workmen to limits indicated by law, ordinances, permits or directions of the designer and owner and shall not exceed those established limits in his operations.

b. The contractor(s) shall not load or permit any part of the structure to be loaded with a weight that will endanger its safety.

c. The contractor(s) shall enforce the designer's and owner’s instructions regarding signs, advertisements, fires and smoking.

d. No firearms, any type of alcoholic beverages, or drugs (other than those prescribed by a physician) will be permitted at the job site.

ARTICLE 39 - CUTTING, PATCHING AND DIGGING

a. The contractor shall do all cutting, fitting or patching of his work that may be required to make its several parts come together properly and fit it to receive or be received by work of other contractors shown upon or reasonably implied by the drawings and specifications for the completed structure, as the designer may direct.

b. Any cost brought about by defective or ill-timed work shall be borne by the party responsible therefor.

c. No contractor shall endanger any work of another contractor by cutting, digging or other means. No contractor shall cut or alter the work of any other contractor without the consent of the designer and the affected contractor(s).

ARTICLE 40 - UTILITIES, STRUCTURES, SIGNS

a. The contractor shall provide necessary and adequate facilities for water, electricity, gas, oil, sewer and other utility services which maybe necessary and required for completion of the project including all utilities required for testing, cleaning, balancing, and sterilization of designated plumbing, mechanical and electrical systems. Any permanent meters installed shall be listed in the contractor’s name until work has a final acceptance. The contractor will be solely responsible for all utility costs prior to final acceptance. Contractor shall contact all affected utility companies prior to bid to determine their requirements to provide temporary and permanent service and include all costs associated with providing those services in their bid. Coordination of the work of the utility companies during construction is the sole responsibility of the contractor.

b. Meters shall be relisted in the owner's name on the day following final acceptance of the Project Expediter's work, and the owner shall pay for services used after that date.

c. The owner shall be reimbursed for all metered utility charges after the meter is relisted in the owner's name and prior to completion and acceptance of the work of **all** contractors. Reimbursement shall be made by the contractor whose work has not been completed and accepted. If the work of two or more contractors has not been completed and accepted, reimbursement to the owner shall be paid by the contractors involved on the basis of assessments by the designer.

d Prior to the operation of permanent systems, the Project Expediter will provide temporary power, lighting, water, and heat to maintain space temperature above freezing, as required for construction operations.

e. All contractors shall have the permanent building systems in sufficient readiness for furnishing temporary climatic control at the time a building is enclosed and secured. The HVAC systems shall maintain climatic control throughout the enclosed portion of the building sufficient to allow completion of the interior finishes of the building. A building shall be considered enclosed and secured when windows**,** doorways (exterior, mechanical, and electrical equipment rooms), and hardware are installed**;** and other openings have protection which will provide reasonable climatic control. The appropriate time to start the mechanical systems and climatic condition shall be jointly determined by the contractor(s), the designer and owner. Use of the equipment in this manner shall be subject to the approval of the Designer and owner and shall in no way affect the warranty requirements of the contractor(s).

f. The electrical contractor shall have the building's permanent power wiring distribution system in sufficient readiness to provide power as required by the HVAC contractor for temporary climatic control.

g. The electrical contractor shall have the building's permanent lighting system ready at the time the general contractor begins interior painting and shall provide adequate lighting in those areas where interior painting and finishing is being performed.

h. Each prime contractor shall be responsible for his permanently fixed service facilities and systems in use during progress of the work. The following procedures shall be strictly adhered to:

1. Prior to final acceptance of work by the State Construction Office, each contractor shall remove and replace any parts of the permanent building systems damaged through use during construction.

2. Temporary filters as recommended by the equipment manufacturer in order to keep the equipment and ductwork clean and free of dust and debris shall be installed in each of the heating and air conditioning units and at each return grille during construction. New filters shall be installed in each unit prior to the owner's acceptance of the work.

3. Extra effort shall be maintained to keep the building and the site adjacent to the building clean and under no circumstances shall air systems be operated if finishing and site work operations are creating dust in excess of what would be considered normal if the building were occupied.

4. It shall be understood that any warranty on equipment presented to the owner shall extend from the day of final acceptance by the owner. The cost of warranting the

equipment during operation in the finishing stages of construction shall be borne by the contractor whose system is utilized.

5. The electrical contractor shall have all lamps in proper working condition at the time of final project acceptance.

i. The Project Expediter shall provide, if required and where directed, a shed for toilet facilities and shall furnish and install in this shed all water closets required for a complete and adequate sanitary arrangement. These facilities will be available to other contractors on the job and shall be kept in a neat and sanitary condition at all times. Chemical toilets are acceptable.

j. The Project Expediter shall, if required by the Supplementary General Conditions and where directed, erect a temporary field office, complete with lights, telephone, heat and air conditioning. A portion of this office shall be partitioned off, of sufficient size, for the use of a resident inspector, should the designer so direct.

k. On multi-story construction projects, the Project Expediter shall provide temporary elevators, lifts, or other special equipment for the general use of all contractors. The cost for such elevators, lifts or other special equipment and the operation thereof shall be included in the Project Expediter's bid.

l. The Project Expediter will erect one sign on the project if required. The sign shall be of sound construction, and shall be neatly lettered with black letters on white background. The sign shall bear the name of the project, and the names of prime contractors on the project, and the name of the designer and consultants. Directional signs may be erected on the owner's property subject to approval of the owner with respect to size, style and location of such directional signs. Such signs may bear the name of the contractor and a directional symbol. No other signs will be permitted except by permission of the owner.

ARTICLE 41 - CLEANING UP

a. The contractors shall keep the building and surrounding area reasonably free from rubbish at all times, and shall remove debris from the site on a timely basis or when directed to do so by the designer or Project Expediter. The Project Expediter shall provide an on site refuse container(s) for the use of all contractors. Each contractor shall remove their rubbish and debris from the building on a daily basis. The Project Expediter shall broom clean the building as required to minimize dust and dirt accumulation.

b. The Project Expediter shall provide and maintain suitable all-weather access to the building**.**

c. Before final inspection and acceptance of the building, each contractor shall clean his portion of the work, including glass, hardware, fixtures, masonry, tile and marble (using no acid), clean and wax all floors as specified, and completely prepare the building for use by the owner, with no cleaning required by the owner.

ARTICLE 42 - GUARANTEE

a. The contractor shall unconditionally guarantee materials and workmanship against patent defects arising from faulty materials, faulty workmanship or negligence for a period of twelve (12) months following the date of final acceptance of the work or beneficial occupancy and shall replace such defective materials or workmanship without cost to the owner.

b. Where items of equipment or material carry a manufacturer's warranty for any period in excess of twelve (12) months, then the manufacturer's warranty shall apply for that particular piece of equipment or material. The contractor shall replace such defective equipment or materials, without cost to the owner, within the manufacturer's warranty period.

c. Additionally, the owner may bring an action for latent defects caused by the negligence of the contractor which is hidden or not readily apparent to the owner at the time of beneficial occupancy or final acceptance, whichever occurred first, in accordance with applicable law.

d. Guarantees for roof, equipment, materials, and supplies shall be stipulated in the specifications sections governing such roof, equipment, materials, or supplies.

ARTICLE 43 - CODES AND STANDARDS

Wherever reference is given to codes, standard specifications or other data published by regulating agencies including, but not limited to, national electrical codes, North Carolina state building codes, federal specifications, ASTM specifications, various institute specifications, etc., it shall be understood that such reference is to the latest edition including addenda published prior to the date of the contract documents.

ARTICLE 44 - INDEMNIFICATION

To the fullest extent permitted by law, the contractor shall indemnify and hold harmless the owner, the designer and the agents, consultants and employees of the owner and designer, from and against all claims, damages, losses and expenses, including, but not limited to, attorneys' fees, arising out of or resulting from the performance or failure of performance of the work, provided that any such claim, damage, loss or expense (1) is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the work itself) including the loss of use resulting there from, and (2) is caused in whole or in part by any negligent act or omission of the contractor, the contractor's subcontractor, or the agents of either the contractor or the contractor's subcontractor. Such obligation shall not be construed to negate, abridge or otherwise reduce any other right or obligation of indemnity which would otherwise exist as to any party or person described in this article.

ARTICLE 45 - TAXES

a. Federal excise taxes do not apply to materials entering into state work (Internal Revenue Code, Section 3442(3)).

b. Federal transportation taxes do not apply to materials entering into state work (Internal Revenue Code, Section 3475(b) as amended).

c. North Carolina sales tax and use tax, as required by law, do apply to materials entering into state work and such costs shall be included in the bid proposal and contract sum.

d. Local option sales and use taxes, as required by law, do apply to materials entering into state work as applicable and such costs shall be included in the bid proposal and contract sum.

e. **Accounting Procedures for Refund of County Sales & Use Tax**

Amount of county sales and use tax paid per contractor's statements:

Contractors performing contracts for state agencies shall give the state agency for whose project the property was purchased a signed statement containing the information listed in G.S. 105-164.14(e).

The Department of Revenue has agreed that in lieu of obtaining copies of sales receipts from contractors, an agency may obtain a certified statement as of April 1, 1991 from the contractor setting forth the date, the type of property and the cost of the property purchased from each vendor, the county in which the vendor made the sale and the amount of local sales and use taxes paid thereon. If the property was purchased out-of-state, the county in which the property was delivered should be listed. The contractor should also be notified that the certified statement may be subject to audit.

In the event the contractors make several purchases from the same vendor, such certified statement must indicate the invoice numbers, the inclusive dates of the invoices, the total amount of the invoices, the counties, and the county sales and use taxes paid thereon.

Name of taxing county: The position of a sale is the retailer's place of business located within a taxing county where the vendor becomes contractually obligated to make the sale. Therefore, it is important that the county tax be reported for the county of sale rather than the county of use.

When property is purchased from out-of-state vendors and the county tax is charged, the county should be identified where delivery is made when reporting the county tax.

Such statement must also include the cost of any tangible personal property withdrawn from the contractor's warehouse stock and the amount of county sales or use tax paid thereon by the contractor.

Similar certified statements by his subcontractors must be obtained by the general contractor and furnished to the claimant.
Contractors are not to include any tax paid on supplies, tools and equipment which they use to perform their contracts and should include only those building materials, supplies, fixtures and equipment which actually become a part of or annexed to the building or structure.

ARTICLE 46 - EQUAL OPPORTUNITY CLAUSE

The non-discrimination clause contained in Section 202 (Federal) Executive Order 11246, as amended by Executive Order 11375, relative to equal employment opportunity for all persons without regard to race, color, religion, sex or national origin, and the implementing rules and regulations prescribed by the secretary of Labor, are incorporated herein.

ARTICLE 47 - EMPLOYMENT OF INDIVIDUALS WITH DISABILITIES

The contractor(s) agree not to discriminate against any employee or applicant for employment because of physical or mental disabilities in regard to any position for which the employee or applicant is qualified. The contractor agrees to take affirmative action to employ, advance in employment and otherwise treat qualified individuals with such disabilities without discrimination based upon their physical or mental disability in all employment practices.

ARTICLE 48 - ASBESTOS-CONTAINING MATERIALS (ACM)

The State of North Carolina has attempted to address all asbestos-containing materials that are to be disturbed in the project. However, there may be other asbestos-containing materials in the work areas that are not to be disturbed and do not create an exposure hazard.

Contractors are reminded of the requirements of instructions under Instructions to Bidders and General Conditions of the Contract, titled Examination of Conditions. Statute 130A, Article 19, amended August 3, 1989, established the Asbestos Hazard Management Program that controls asbestos abatement in North Carolina. The latest edition of *Guideline Criteria for Asbestos Abatement* from the State Construction Office is to be incorporated in all asbestos abatement projects for the Capital Improvement Program.

ARTICLE 49 - MINORITY BUSINESS PARTICIPATION

GS 143-128.2 establishes a ten percent (10%) goal for participation by minority businesses in total value of work for each State building project. The document, *Guidelines for Recruitment and Selection of Minority Businesses for Participation in State Construction Contracts* including Affidavits and Appendix E are hereby incorporated into and made a part of this contract.

ARTICLE 50 – CONTRACTOR EVALUATION

The contractor's overall work performance on the project shall be fairly evaluated in accordance with the State Building Commission policy and procedures, for determining qualifications to bid on future State capital improvement projects. In addition to final evaluation, interim evaluation may be prepared during the progress of project. The document, Contractor Evaluation Procedures, is hereby incorporated and made a part of this contract. The owner may request the contractor's comments to evaluate the designer.

ARTICLE 51 – GIFTS

Pursuant to N.C. Gen. Stat. § 133-32, it is unlawful for any vendor or contractor (i.e. architect, bidder, contractor, construction manager, design professional, engineer, subcontractor, supplier, vendor, etc.), to make gifts or to give favors to any State employee. This prohibition covers those vendors and contractors who: (1) have a contract with a governmental agency; or (2) have performed under such a contract within the past year; or (3) anticipate bidding on such a contract in the future. For additional information regarding the specific requirements and exemptions, vendors and contractors are encouraged to review G.S. Sec. 133-32.

During the construction of the Project, the Contractor is prohibited from making gifts to any of the Owner's employees, Owner's project representatives (architect, engineers, construction manager and their employees), employees of the State Construction Office and/or any other State employee that may have any involvement, influence, responsibilities, oversight, management and/or duties that pertain to and/or relate to the contract administration, financial administration and/or disposition of claims arising from and/or relating to the Contract and/or Project.

ARTICLE 52 – AUDITING-ACCESS TO PERSONS AND RECORDS

In accordance with N.C. General Statute 147-64.7, the State Auditor shall have access to Contractor's officers, employees, agents and/or other persons in control of and/or responsible for the Contractor's records that relate to this Contracts for purposes of conducting audits under the referenced statute. The Owner's internal auditors shall also have the right to access and copy the Contractor's records relating to the Contract and Project during the term of the Contract and within two years following the completion of the Project/close-out of the Contract to verify accounts, accuracy, information, calculations and/or data affecting and/or

relating to Contractor's requests for payment, requests for change orders, change orders, claims for extra work, requests for time extensions and related claims for delay/extended general conditions costs, claims for lost productivity, claims for loss efficiency, claims for idle equipment or labor, claims for price/cost escalation, pass-through claims of subcontractors and/or suppliers, and/or any other type of claim for payment or damages from Owner and/or its project representatives.

ARTICLE 53 – NORTH CAROLINA FALSE CLAIMS ACT

The North Carolina False Claims Act ("NCFCA"), N.C Gen. Stat. § 1-605 through 1-618, applies to this Contract. The Contractor should familiarize itself with the entire NCFCA and should seek the assistance of an attorney if it has any questions regarding the NCFCA and its applicability to any requests, demands and/or claims for payment its submits to the State through the contracting state agency, institution, university or community college.

The purpose of the NCFCA "is to deter persons from knowingly causing or assisting in causing the State to pay claims that are false or fraudulent and to provide remedies in the form of treble damages and civil penalties when money is obtained from the State by reason of a false or fraudulent claim." (Section 1-605(b).) A contractor's liability under the NCFCA may arise from, but is not limited to: requests for payment, invoices, billing, claims for extra work, requests for change orders, requests for time extensions, claims for delay damages/extended general conditions costs, claims for loss productivity, claims for loss efficiency, claims for idle equipment or labor, claims for price/cost escalation, pass-through claims of subcontractors and/or suppliers, documentation used to support any of the foregoing requests or claims, and/or any other request for payment from the State through the contracting state agency, institution, university or community college. The parts of the NCFCA that are most likely to be enforced with respect to this type of contract are as follows:

- A "claim" is "[a]ny request or demand, whether under a contract or otherwise, for money or property and whether or not the State has title to the money or property that (i) is presented to an officer, employee, or agent of the State or (ii) is made to a contractor … if the money or property is to be spent or used on the State's behalf or to advance a State program or interest and if the State government: (a) provides or has provided any portion of the money or property that is requested or demanded; or (b) will reimburse such contractor … for any portion of the money or property which is requested or demanded." (Section 1-606(2).)

- "Knowing" and "knowingly." – Whenever a person, with respect to information, does any of the following: (a) Has actual knowledge of the information; (b) Acts in deliberate ignorance of the truth or falsity of the information; and/or (c) Acts in reckless disregard of the truth or falsity of the information. (Section 1-606(4).) Proof of specific intent to defraud is not required. (Section 1-606(4).)

- "Material" means having a natural tendency to influence, or be capable of influencing, the payment or receipt of money or property. (Section 1-606(4).)

- Liability. – "Any person who commits any of the following acts shall be liable to the State for three times the amount of damages that the State sustains because of the act of that person[:] … (1) Knowingly presents or causes to be presented a false or fraudulent claim for payment or approval. (2) Knowingly makes, uses, or causes to be made or used, a false record or statement material to a false or fraudulent claim. (3) Conspires to commit a violation of subdivision (1), (2) …" (Section 1-607(a)(1), (2).)

- The NCFCA shall be interpreted and construed so as to be consistent with the federal False Claims Act, 31 U.S.C. § 3729, et seq., and any subsequent amendments to that act. (Section 1-616(c).)

Finally, the contracting state agency, institution, university or community college may refer any suspected violation of the NCFCA by the Contractor to the Attorney General's Office for investigation. Under Section 1-608(a), the Attorney General is responsible for investigating any violation of NCFCA, and may bring a civil action against the Contractor under the NCFCA. The Attorney General's investigation and any civil action relating thereto are independent and not subject to any dispute resolution provision set forth in this Contract. (See Section 1-608(a).)

ARTICLE 54 – TERMINATION FOR CONVENIENCE

Owner may at any time and for any reason terminate Contractor's services and work at Owner's convenience. Upon receipt of such notice, Contractor shall, unless the notice directs otherwise, immediately discontinue the work and placing of orders for materials, facilities and supplies in connection with the performance of this Agreement.

Upon such termination, Contractor shall be entitled to payment only as follows: (1) the actual cost of the work completed in conformity with this Agreement; plus, (2) such other costs actually incurred by Contractor as are permitted by the prime contract and approved by Owner; (3) plus ten percent (10%) of the cost of the work referred to in subparagraph (1) above for overhead and profit. There shall be deducted from such sums as provided in this subparagraph the amount of any payments made to Contractor prior to the date of the termination of this Agreement. Contractor shall not be entitled to any claim or claim of lien against Owner for any additional compensation or damages in the event of such termination and payment.

SUPPLEMENTARY GENERAL CONDITIONS

TIME OF COMPLETION

The Contractor shall commence work to be performed under this Contract on a date to be specified in written order from the Designer/Owner and shall fully complete all work hereunder within **Four hundred and sixty five (465)** consecutive calendar days from the Notice to Proceed. For each day in excess of the above number of days, the Contractor shall pay the Owner the amount of **Two Hundred and Fifty Dollars ($250.00)** as liquidated damages reasonably estimated in advance to cover the losses to be incurred by the Owner should the Contractor fail to complete the Work within the time specified.

If the Contractor is delayed at anytime in the progress of his work by any act or negligence of the Owner, his employees or his separate contractor, by changes ordered in the work; by abnormal weather conditions; by any causes beyond the Contractor's control or by other causes deemed justifiable by Owner, then the contract time may be reasonably extended in a written order from the Owner upon written request from the contractor within ten days following the cause for delay. Time extensions for weather delays, acts of God, labor disputes, fire, delays in transportation, unavoidable casualties or other delays which are beyond the control of the Owner do not entitle the Contractor to compensable damages for delays. Any contractor claim for compensable damages for delays is limited to delays caused solely by the owner or its agents.

CONTRUCTION SCHEDULE

To be determined and coordinated between the contractor and the owner.

WORKING HOURS

Normal working hours are anticipated for the scope of work indicated in this project. The working hours will be coordinated during the preconstruction meeting. Other hours may be permitted with approval by owning agency.

SAFETY TRAINING

All contractor employees, including subcontractors, shall participate in a mandatory safety training orientation (estimated 15 minutes) prior to working on the jobsite.

PAYMENTS

Applications for payment shall be submitted by the 20th of each month to the owner and designer on standard AIA Forms G702 and G703.

UTILITIES

The contractor shall coordinate the use of water and electricity for construction purposes with the owner.

SECURITY

The Contractor shall furnish and require his employees to wear a distinctive identification badge. Such badge shall show the name of the employee and employee's name or identifying number. The Contractor shall require identification of employees of all subcontractors, authorized representative, and other authorized visitors on the site.

USE OF SITE

Parking is limited at The Eaddy Building. Contractors shall only park in designated parking spaces and shall not block the loading dock.

No photographs of the project or any part of it will be allowed without the expressed written consent of the Owner.

The Contractor shall not disclose in any advertisement, publicity, or promotional material without the prior written consent of the Owner in each instance that the Contractor is performing or has performed the work.

The Contractor is permitted to use the Owner's toilet and drinking water facilities.

The Contractor shall remove trash and debris from the staging area and project site at the end of each day of work. No items may be stored outside of the staging area and project site.

NO SMOKING POLICY
Smoking is not allowed on the property.

REQUIRED DOCUMENTS
Contractors shall include HUB participation forms with their bid and indicate their HUB status on the bid form.

PERFORMANCE AND PAYMENT BONDS
Contractor shall furnish a Performance Bond and Payment Bond executed by a surety company authorized to do business in North Carolina. The bonds shall be in the full contract amount. Bonds shall be executed in the form bound with these specifications (Forms 307 & 308). An authorized agent of the bonding company who is licensed to do business in North Carolina shall countersign all bonds.

MINORITY BUSINESS PARTICIPATION
Provide with the bid - Under GS 143-128.2(c) the undersigned bidder shall identify **on its bid** (Identity of Minority Business Participation Form) the minority businesses that it will use on the project with the total dollar value of the bids that will be performed by the minority businesses. **Also** list the good faith efforts (Affidavit **A**) made to solicit minority participation in the bid effort.

NOTE: A contractor that performs all of the work with its own workforce may submit an Affidavit (**B)** to that effect in lieu of Affidavit (**A)** required above. The MB Participation Form must still be submitted even if there is zero participation.

After the bid opening - The Owner will consider all bids and alternates and determine the lowest responsible, responsive bidder. Upon notification of being the apparent low bidder, the bidder shall then file within 72 hours of the notification of being the apparent lowest bidder, the following:

An Affidavit (**C**) that includes a description of the portion of work to be executed by minority businesses, expressed as a percentage of the total contract price, which is equal to or more than the 10% goal established. This affidavit shall give rise to the presumption that the bidder has made the required good faith effort and Affidavit **D** is not necessary;

OR

If less than the 10% goal, Affidavit (**D**) of its good faith effort to meet the goal shall be provided. The document must include evidence of all good faith efforts that were implemented, including any advertisements, solicitations and other specific actions demonstrating recruitment and selection of minority businesses for participation in the contract.

Note: Bidders must submit **with their bid** the Identification of Minority Business Participation Form listing all MB contractors, vendors and suppliers that will be used. If there is no MB participation, then enter none or zero on

the form. Affidavit A **or** Affidavit B, as applicable, also must be submitted with the bid. Failure to file a required affidavit or documentation with the bid or after being notified apparent low bidder may be grounds for rejection of the bid.

FORM OF PROPOSAL

F O R M O F P R O P O S A L

Eaddy Building HVAC & Lab Exhaust Upgrades & Repairs Contract:_____

NC Department of Agriculture & Consumer Services Bidder: _____

SCO-ID # 22-24510-01 Code: 42017 Item: 4404 Date:_____

The undersigned, as bidder, hereby declares that the only person or persons interested in this proposal as principal or principals is or are named herein and that no other person than herein mentioned has any interest in this proposal or in the contract to be entered into; that this proposal is made without connection with any other person, company or parties making a bid or proposal; and that it is in all respects fair and in good faith without collusion or fraud. The bidder further declares that he has examined the site of the work and the contract documents relative thereto, and has read all special provisions furnished prior to the opening of bids; that he has satisfied himself relative to the work to be performed. The bidder further declares that he and his subcontractors have fully complied with NCGS 64, Article 2 in regards to E-Verification as required by Section 2.(c) of Session Law 2013-418, codified as N.C. Gen. Stat. § 143-129(j).

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The Bidder proposes and agrees if this proposal is accepted to contract with the

State of North Carolina through the North Carolina Department of Agriculture & Consumer Services

in the form of contract specified below, to furnish all necessary materials, equipment, machinery, tools, apparatus, means of transportation and labor necessary to complete the construction of

Eaddy Building HVAC & Lab Exhaust Upgrades & Repairs

in full in complete accordance with the plans, specifications and contract documents, to the full and entire satisfaction of the State of North Carolina, and the

North Carolina Department of Agriculture & Consumer Services

with a definite understanding that no money will be allowed for extra work except as set forth in the General Conditions and the contract documents, for the sum of:

SINGLE PRIME CONTRACT:_____

Base Bid:

_____Dollars($)_____

General Subcontractor:

_____Lic_____

Plumbing Subcontractor:

_____Lic_____

Mechanical Subcontractor:

_____Lic_____

Electrical Subcontractor:

_____Lic_____

GS143-128(d) requires all single prime bidders to identify their subcontractors for the above subdivisions of work. A contractor whose bid is accepted shall not substitute any person as subcontractor in the place of the subcontractor listed in the original bid, except (i) if the listed subcontractor's bid is later determined by the contractor to be non-responsible or non-responsive or the listed subcontractor refuses to enter into a contract for the complete performance of the bid work, or (ii) with the approval of the awarding authority for good cause shown by the contractor.

ALTERNATES:

Should any of the alternates as described in the contract documents be accepted, the amount written below shall be the amount to be "added to" or "deducted from" the base bid. (Strike out "Add" or "Deduct" as appropriate.)

Alternate Bid 1 State the amount to install of a ductless split system in 137 Mechanical Room to cool the existing UPS batteries.

(Add) _____ Dollars ($) _____

Alternate Bid 2 State the amount to install a second chilled water pump to provide 100% chilled water pumping redundancy.

(Add) _____ Dollars ($) _____

Alternate Bid 3 State the amount to install variable frequency drives for the replacement exhaust fans.

(Add) _____ Dollars ($) _____

Alternate Bid 4 State the amount to retrofit AHU-1A & AHU-1B with inverter-duty supply fan motors and variable frequency drives.

(Add) _____ Dollars ($) _____

GENERAL CONTRACT:

The bidder further proposes and agrees hereby to commence work under this contract on a date to be specified in a written order of the designer and shall fully complete all work thereunder within the time specified in the Supplementary General Conditions Article 23. Applicable liquidated damages amount is also stated in the Supplementary General Conditions Article 23.

MINORITY BUSINESS PARTICIPATION REQUIREMENTS

Provide with the bid - Under GS 143-128.2(c) the undersigned bidder shall identify **on its bid** (Identification of Minority Business Participation Form) the minority businesses that it will use on the project with the total dollar value of the bids that will be performed by the minority businesses. **Also** list the good faith efforts (Affidavit **A**) made to solicit minority participation in the bid effort.

NOTE: A contractor that performs all of the work with its own workforce may submit an Affidavit (**B)** to that effect in lieu of Affidavit (**A)** required above. The MB Participation Form must still be submitted even if there is zero participation.

After the bid opening - The Owner will consider all bids and alternates and determine the lowest responsible, responsive bidder. Upon notification of being the apparent low bidder, the bidder shall then file within 72 hours of the notification of being the apparent lowest bidder, the following:

An Affidavit (**C**) that includes a description of the portion of work to be executed by minority businesses, expressed as a percentage of the total contract price, which is equal to or more than the 10% goal established. This affidavit shall give rise to the presumption that the bidder has made the required good faith effort and Affidavit **D** is not necessary;

*** OR ***

If less than the 10% goal, Affidavit (**D**) of its good faith effort to meet the goal shall be provided. The document must include evidence of all good faith efforts that were implemented, including any advertisements, solicitations and other specific actions demonstrating recruitment and selection of minority businesses for participation in the contract.

Note: Bidders must always submit **with their bid** the Identification of Minority Business Participation Form listing all MB contractors, vendors and suppliers that will be used. If there is no MB participation, then enter none or zero on the form. Affidavit A **or** Affidavit B, as applicable, also must be submitted with the bid. Failure to file a required affidavit or documentation with the bid or after being notified apparent low bidder is grounds for rejection of the bid.

Proposal Signature Page

The undersigned further agrees that in the case of failure on his part to execute the said contract and the bonds within ten (10) consecutive calendar days after being given written notice of the award of contract, the certified check, cash or bid bond accompanying this bid shall be paid into the funds of the owner's account set aside for the project, as liquidated damages for such failure; otherwise the certified check, cash or bid bond accompanying this proposal shall be returned to the undersigned.

Respectfully submitted this day of _____

_____
(Name of firm or corporation making bid)

WITNESS:

_____
(Proprietorship or Partnership)

By:_____
Signature

Name: _____
Print or type

Title_____
(Owner/Partner/Pres./V.Pres)

Address_____

_____

ATTEST:

By:_____

Title:_____
(Corp. Sec. or Asst. Sec. only)

License No._____

Federal I.D. No. _____

Email Address: _____

(CORPORATE SEAL)

Addendum received and used in computing bid:

Addendum No. 1 _____ Addendum No. 3 _____ Addendum No. 5_____ Addendum No. 6_____

Addendum No. 2 _____ Addendum No. 4 _____ Addendum No. 6 _____ Addendum No. 7 _____

MBE FORMS

Identification of HUB Certified/ Minority Business Participation

I,_____,
(Name of Bidder)
do hereby certify that on this project, we will use the following HUB Certified/ minority business as construction subcontractors, vendors, suppliers or providers of professional services.

Firm Name, Address and Phone #	Work Type	*Minority Category	**HUB Certified (Y/N)

*Minority categories: Black, African American (**B**), Hispanic (**H**), Asian American (**A**) American Indian (**I**), Female (**F**) Socially and Economically Disadvantaged (**D**)

**** HUB Certification with the state HUB Office required to be counted toward state participation goals.**

The total value of minority business contracting will be ($)_____.

State of North Carolina AFFIDAVIT A – Listing of Good Faith Efforts

County of _____

(Name of Bidder)

Affidavit of_____

I have made a good faith effort to comply under the following areas checked:

Bidders must earn at least 50 points from the good faith efforts listed for their bid to be considered responsive. (1 NC Administrative Code 30 I.0101)

- ❑ **1 – (10 pts)** Contacted minority businesses that reasonably could have been expected to submit a quote and that were known to the contractor, or available on State or local government maintained lists, at least 10 days before the bid date and notified them of the nature and scope of the work to be performed.
- ❑ **2 --(10 pts)** Made the construction plans, specifications and requirements available for review by prospective minority businesses, or providing these documents to them at least 10 days before the bids are due.
- ❑ **3** – **(15 pts)** Broken down or combined elements of work into economically feasible units to facilitate minority participation.
- ❑ **4 – (10 pts)** Worked with minority trade, community, or contractor organizations identified by the Office of Historically Underutilized Businesses and included in the bid documents that provide assistance in recruitment of minority businesses.
- ❑ **5** – **(10 pts)** Attended prebid meetings scheduled by the public owner.
- ❑ **6** – **(20 pts)** Provided assistance in getting required bonding or insurance or provided alternatives to bonding or insurance for subcontractors.
- ❑ **7 – (15 pts)** Negotiated in good faith with interested minority businesses and did not reject them as unqualified without sound reasons based on their capabilities. Any rejection of a minority business based on lack of qualification should have the reasons documented in writing.
- ❑ **8** – **(25 pts)** Provided assistance to an otherwise qualified minority business in need of equipment, loan capital, lines of credit, or joint pay agreements to secure loans, supplies, or letters of credit, including waiving credit that is ordinarily required. Assisted minority businesses in obtaining the same unit pricing with the bidder's suppliers in order to help minority businesses in establishing credit.
- ❑ **9** – **(20 pts)** Negotiated joint venture and partnership arrangements with minority businesses in order to increase opportunities for minority business participation on a public construction or repair project when possible.
- ❑ **10 - (20 pts)** Provided quick pay agreements and policies to enable minority contractors and suppliers to meet cash-flow demands.

The undersigned, if apparent low bidder, will enter into a formal agreement with the firms listed in the Identification of Minority Business Participation schedule conditional upon scope of contract to be executed with the Owner. Substitution of contractors must be in accordance with GS143-128.2(d) Failure to abide by this statutory provision will constitute a breach of the contract.

The undersigned hereby certifies that he or she has read the terms of the minority business commitment and is authorized to bind the bidder to the commitment herein set forth.

Date:_____Name of Authorized Officer:_____

Signature:_____

Title:_____

SEAL

State of_____, County of_____

Subscribed and sworn to before me this _____day of _____20____

Notary Public_____

My commission expires _____

State of North Carolina --AFFIDAVIT B-- Intent to Perform Contract with Own Workforce.

County of _____

Affidavit of_____
(Name of Bidder)

I hereby certify that it is our intent to perform 100% of the work required for the _____

_____contract.
(Name of Project)

In making this certification, the Bidder states that the Bidder does not customarily subcontract elements of this type project, and normally performs and has the capability to perform and will perform all elements of the work on this project with his/her own current work forces; and

The Bidder agrees to provide any additional information or documentation requested by the owner in support of the above statement. The Bidder agrees to make a Good Faith Effort to utilize minority suppliers where possible.

The undersigned hereby certifies that he or she has read this certification and is authorized to bind the Bidder to the commitments herein contained.

Date:_____Name of Authorized Officer:_____

Signature:_____

Title:_____

SEAL

State of _____, County of_____

Subscribed and sworn to before me this _____day of _____20___

Notary Public _____

My commission expires_____

Do not submit with bid Do not submit with bid Do not submit with bid Do not submit with bid

State of North Carolina - AFFIDAVIT C - Portion of the Work to be Performed by HUB Certified/Minority Businesses

County of _____

(Note this form is to be submitted only by the apparent lowest responsible, responsive bidder.)

If the portion of the work to be executed by HUB certified/minority businesses as defined in GS143-128.2(g) and 128.4(a),(b),(e) is equal to or greater than 10% of the bidders total contract price, then the bidder must complete this affidavit.
This affidavit shall be provided by the apparent lowest responsible, responsive bidder within **72 hours** after notification of being low bidder.

Affidavit of _____ I do hereby certify that on the
(Name of Bidder)

_____
(Project Name)

Project ID#_____ Amount of Bid $_____

I will expend a minimum of _____% of the total dollar amount of the contract with minority business enterprises. Minority businesses will be employed as construction subcontractors, vendors, suppliers or providers of professional services. Such work will be subcontracted to the following firms listed below. Attach additional sheets if required

Name and Phone Number	*Minority Category	**HUB Certified Y/N	Work Description	Dollar Value

*Minority categories: Black, African American (**B**), Hispanic (**H**), Asian American (**A**) American Indian (**I**), Female (**F**) Socially and Economically Disadvantaged (**D**)

**** HUB Certification with the state HUB Office required to be counted toward state participation goals.**

Pursuant to GS143-128.2(d), the undersigned will enter into a formal agreement with Minority Firms for work listed in this schedule conditional upon execution of a contract with the Owner. Failure to fulfill this commitment may constitute a breach of the contract.

The undersigned hereby certifies that he or she has read the terms of this commitment and is authorized to bind the bidder to the commitment herein set forth.

Date:_____ Name of Authorized Officer:_____

SEAL

Signature:_____

Title:_____

State of _____, County of _____
Subscribed and sworn to before me this _____day of _____20____
Notary Public_____
My commission expires_____

State of North Carolina AFFIDAVIT D – Good Faith Efforts

County of _____

(Note this form is to be submitted only by the apparent lowest responsible, responsive bidder.)

If the goal of 10% participation by HUB Certified/ minority business **is not** achieved, the Bidder shall provide the following documentation to the Owner of his good faith efforts:

Affidavit of _____ I do hereby certify that on the
(Name of Bidder)

_____
(Project Name)

Project ID#_____ Amount of Bid $_____

I will expend a minimum of _____% of the total dollar amount of the contract with HUB certified/ minority business enterprises. Minority businesses will be employed as construction subcontractors, vendors, suppliers or providers of professional services. Such work will be subcontracted to the following firms listed below. (Attach additional sheets if required)

Name and Phone Number	*Minority Category	**HUB Certified Y/N	Work Description	Dollar Value

*Minority categories: Black, African American (**B**), Hispanic (**H**), Asian American (**A**) American Indian (**I**), Female (**F**) Socially and Economically Disadvantaged (**D**)

**** HUB Certification with the state HUB Office required to be counted toward state participation goals.**

Examples of documentation that may be required to demonstrate the Bidder's good faith efforts to meet the goals set forth in these provisions include, but are not necessarily limited to, the following:

A. Copies of solicitations for quotes to at least three (3) minority business firms from the source list provided by the State for each subcontract to be let under this contract (if 3 or more firms are shown on the source list). Each solicitation shall contain a specific description of the work to be subcontracted, location where bid documents can be reviewed, representative of the Prime Bidder to contact, and location, date and time when quotes must be received.

B. Copies of quotes or responses received from each firm responding to the solicitation.

C. A telephone log of follow-up calls to each firm sent a solicitation.

D. For subcontracts where a minority business firm is not considered the lowest responsible sub-bidder, copies of quotes received from all firms submitting quotes for that particular subcontract.

E. Documentation of any contacts or correspondence to minority business, community, or contractor organizations in an attempt to meet the goal.

F. Copy of pre-bid roster

G. Letter documenting efforts to provide assistance in obtaining required bonding or insurance for minority business.

H. Letter detailing reasons for rejection of minority business due to lack of qualification.

I. Letter documenting proposed assistance offered to minority business in need of equipment, loan capital, lines of credit, or joint pay agreements to secure loans, supplies, or letter of credit, including waiving credit that is ordinarily required.

Failure to provide the documentation as listed in these provisions may result in rejection of the bid and award to the next lowest responsible and responsive bidder.

Pursuant to GS143-128.2(d), the undersigned will enter into a formal agreement with Minority Firms for work listed in this schedule conditional upon execution of a contract with the Owner. Failure to fulfill this commitment may constitute a breach of the contract.

The undersigned hereby certifies that he or she has read the terms of this commitment and is authorized to bind the bidder to the commitment herein set forth.

Date:_____Name of Authorized Officer:_____

Signature:_____

Title:_____

SEAL

State of_____, County of _____

Subscribed and sworn to before me this _____day of _____20____

Notary Public_____

My commission expires _____

MBE GUIDELINES

GUIDELINES FOR RECRUITMENT AND SELECTION OF MINORITY BUSINESSES FOR PARTICIPATION IN STATE CONSTRUCTION CONTRACTS

In accordance with G.S. 143-128.2 (effective January 1, 2002) these guidelines establish goals for minority participation in single-prime bidding, separate-prime bidding, construction manager at risk, and alternative contracting methods, on State construction projects in the amount of $300,000 or more. The legislation provides that the State shall have a verifiable ten percent (10%) goal for participation by minority businesses in the total value of work for each project for which a contract or contracts are awarded. These requirements are published to accomplish that end.

SECTION A: INTENT

It is the intent of these guidelines that the State of North Carolina, as awarding authority for construction projects, and the contractors and subcontractors performing the construction contracts awarded shall cooperate and in good faith do all things legal, proper and reasonable to achieve the statutory goal of ten percent (10%) for participation by minority businesses in each construction project as mandated by GS 143-128.2. Nothing in these guidelines shall be construed to require contractors or awarding authorities to award contracts or subcontracts to or to make purchases of materials or equipment from minority-business contractors or minority-business subcontractors who do not submit the lowest responsible, responsive bid or bids.

SECTION B: DEFINITIONS

1. Minority - a person who is a citizen or lawful permanent resident of the United States and who is:
   a. Black, that is, a person having origins in any of the black racial groups in Africa;
   b. Hispanic, that is, a person of Spanish or Portuguese culture with origins in Mexico, South or Central America, or the Caribbean Islands, regardless of race;
   c. Asian American, that is, a person having origins in any of the original peoples of the Far East, Southeast Asia and Asia, the Indian subcontinent, the Pacific Islands;
   d. American Indian, that is, a person having origins in any of the original peoples of North America; or
   e. Female

2. Minority Business - means a business:
   a. In which at least fifty-one percent (51%) is owned by one or more minority persons, or in the case of a corporation, in which at least fifty-one percent (51%) of the stock is owned by one or more minority persons or socially and economically disadvantaged individuals; and
   b. Of which the management and daily business operations are controlled by one or more of the minority persons or socially and economically disadvantaged individuals who own it.

3. Socially and economically disadvantaged individual - means the same as defined in 15 U.S.C. 637. "Socially disadvantaged individuals are those who have been subjected to racial or ethnic prejudice or cultural bias because of their identity as a member of a group without regard to their individual qualities". "Economically disadvantaged individuals are those socially disadvantaged individuals whose ability to compete in the free enterprise system has been impaired due to diminished capital and credit opportunities as compared to others in the same business area who are not socially disadvantaged".

4. Public Entity - means State and all public subdivisions and local governmental units.

5. Owner - The State of North Carolina, through the Agency/Institution named in the contract.

6. Designer – Any person, firm, partnership, or corporation, which has contracted with the State of North Carolina to perform architectural or engineering, work.

7. Bidder - Any person, firm, partnership, corporation, association, or joint venture seeking to be awarded a public contract or subcontract.

8. Contract - A mutually binding legal relationship or any modification thereof obligating the seller to furnish equipment, materials or services, including construction, and obligating the buyer to pay for them.

9. Contractor - Any person, firm, partnership, corporation, association, or joint venture which has contracted with the State of North Carolina to perform construction work or repair.

10. Subcontractor - A firm under contract with the prime contractor or construction manager at risk for supplying materials or labor and materials and/or installation. The subcontractor may or may not provide materials in his subcontract.

SECTION C: RESPONSIBILITIES

1. Office for Historically Underutilized Businesses, Department of Administration (hereinafter referred to as HUB Office).

   The HUB Office has established a program, which allows interested persons or businesses qualifying as a minority business under G.S. 143-128.2, to obtain certification in the State of North Carolina procurement system. The information provided by the minority businesses will be used by the HUB Office to:
   a. Identify those areas of work for which there are minority businesses, as requested.
   b. Make available to interested parties a list of prospective minority business contractors and subcontractors.
   c. Assist in the determination of technical assistance needed by minority business contractors.

   In addition to being responsible for the certification/verification of minority businesses that want to participate in the State construction program, the HUB Office will:
   (1) Maintain a current list of minority businesses. The list shall include the areas of work in which each minority business is interested.
   (2) Inform minority businesses on how to identify and obtain contracting and subcontracting opportunities through the State Construction Office and other public entities.
   (3) Inform minority businesses of the contracting and subcontracting process for public construction building projects.
   (4) Work with the North Carolina trade and professional organizations to improve the ability of minority businesses to compete in the State construction projects.
   (5) The HUB Office also oversees the minority business program by:
      a. Monitoring compliance with the program requirements.
      b. Assisting in the implementation of training and technical assistance programs.
      c. Identifying and implementing outreach efforts to increase the utilization of minority businesses.
      d. Reporting the results of minority business utilization to the Secretary of the Department of Administration, the Governor, and the General Assembly.

2. State Construction Office
   The State Construction Office will be responsible for the following:

   a. Furnish to the HUB Office a minimum of twenty-one days prior to the bid opening the following:
      (1) Project description and location;
      (2) Locations where bidding documents may be reviewed;
      (3) Name of a representative of the owner who can be contacted during the advertising period to advise who the prospective bidders are;
      (4) Date, time and location of the bid opening.
      (5) Date, time and location of prebid conference, if scheduled.

   b. Attending scheduled prebid conference, if necessary, to clarify requirements of the general statutes regarding minority-business participation, including the bidders' responsibilities.

c. Reviewing the apparent low bidders' statutory compliance with the requirements listed in the proposal, that must be complied with, if the bid is to be considered as responsive, prior to award of contracts. The State reserves the right to reject any or all bids and to waive informalities.
d. Reviewing of minority business requirements at Preconstruction conference**.**
e. Monitoring of contractors' compliance with minority business requirements in the contract documents during construction.
f. Provide statistical data and required reports to the HUB Office.
g. Resolve any protest and disputes arising after implementation of the plan, in conjunction with the HUB Office.

3. Owner
Before awarding a contract, owner shall do the following:

a. Develop and implement a minority business participation outreach plan to identify minority businesses that can perform public building projects and to implement outreach efforts to encourage minority business participation in these projects to include education, recruitment, and interaction between minority businesses and non-minority businesses.
b. Attend the scheduled prebid conference.
c. At least 10 days prior to the scheduled day of bid opening, notify minority businesses that have requested notices from the public entity for public construction or repair work and minority businesses that otherwise indicated to the Office for Historically Underutilized Businesses an interest in the type of work being bid or the potential contracting opportunities listed in the proposal. The notification shall include the following:
    1. A description of the work for which the bid is being solicited.
    2. The date, time, and location where bids are to be submitted.
    3. The name of the individual within the owner's organization who will be available to answer questions about the project.
    4. Where bid documents may be reviewed.
    5. Any special requirements that may exist.
d. Utilize other media, as appropriate, likely to inform potential minority businesses of the bid being sought.
e. Maintain documentation of any contacts, correspondence, or conversation with minority business firms made in an attempt to meet the goals.
f. Review, jointly with the designer, all requirements of G.S. 143-128.2(c) and G.S. 143-128.2(f) – (i.e. bidders' proposals for identification of the minority businesses that will be utilized with corresponding total dollar value of the bid and affidavit listing good faith efforts, or affidavit of self-performance of work, if the contractor will perform work under contract by its own workforce) - prior to recommendation of award to the State Construction Office.
g. Evaluate documentation to determine good faith effort has been achieved for minority business utilization prior to recommendation of award to State Construction Office.
h. Review prime contractors' pay applications for compliance with minority business utilization commitments prior to payment**.**
i. Make documentation showing evidence of implementation of Owner's responsibilities available for review by State Construction Office and HUB Office, upon request

4. Designer
Under the single-prime bidding, separate prime bidding, construction manager at risk, or alternative contracting method, the designer will:

a. Attend the scheduled prebid conference to explain minority business requirements to the prospective bidders.
b. Assist the owner to identify and notify prospective minority business prime and subcontractors of potential contracting opportunities.
c. Maintain documentation of any contacts, correspondence, or conversation with minority business firms made in an attempt to meet the goals.
d. Review jointly with the owner, all requirements of G.S. 143-128.2(c) and G.S.143-128.2(f) – (i.e. bidders' proposals for identification of the minority businesses that will be utilized with

corresponding total dollar value of the bid and affidavit listing Good Faith Efforts, or affidavit of self-performance of work, if the contractor will perform work under contract by its own workforce) - prior to recommendation of award.

e. During construction phase of the project, review "MBE Documentation for Contract Payment" – (Appendix E) for compliance with minority business utilization commitments. Submit Appendix E form with monthly pay applications to the owner and forward copies to the State Construction Office.
f. Make documentation showing evidence of implementation of Designer's responsibilities available for review by State Construction Office and HUB Office, upon request.

5. Prime Contractor(s), CM at Risk, and Its First-Tier Subcontractors
Under the single-prime bidding, the separate-prime biding, construction manager at risk and alternative contracting methods, contractor(s) will:

a. Attend the scheduled prebid conference.
b. Identify or determine those work areas of a subcontract where minority businesses may have an interest in performing subcontract work.
c. At least ten (10) days prior to the scheduled day of bid opening, notify minority businesses of potential subcontracting opportunities listed in the proposal. The notification will include the following:
   (1) A description of the work for which the subbid is being solicited.
   (2) The date, time and location where subbids are to be submitted.
   (3) The name of the individual within the company who will be available to answer questions about the project.
   (4) Where bid documents may be reviewed.
   (5) Any special requirements that may exist, such as insurance, licenses, bonds and financial arrangements.

   If there are more than three (3) minority businesses in the general locality of the project who offer similar contracting or subcontracting services in the specific trade, the contractor(s) shall notify three (3), but may contact more, if the contractor(s) so desires.
d. During the bidding process, comply with the contractor(s) requirements listed in the proposal for minority participation.
e. Identify on the bid**,** the minority businesses that will be utilized on the project with corresponding total dollar value of the bid and affidavit listing good faith efforts as required by G.S. 143-128.2(c) and G.S. 143-128.2(f).
f. Make documentation showing evidence of implementation of PM, CM-at-Risk and First-Tier Subcontractor responsibilities available for review by State Construction Office and HUB Office, upon request.
g. Upon being named the apparent low bidder, the Bidder shall provide one of the following: (1) an affidavit (Affidavit C) that includes a description of the portion of work to be executed by minority businesses, expressed as a percentage of the total contract price, which is equal to or more than the applicable goal; (2) if the percentage is not equal to the applicable goal, then documentation of all good faith efforts taken to meet the goal. Failure to comply with these requirements is grounds for rejection of the bid and award to the next lowest responsible and responsive bidder.
h. The contractor(s) shall identify the name(s) of minority business subcontractor(s) and corresponding dollar amount of work on the schedule of values. The schedule of values shall be provided as required in Article 31 of the General Conditions of the Contract to facilitate payments to the subcontractors.
i. The contractor(s) shall submit with each monthly pay request(s) and final payment(s), "MBE Documentation for Contract Payment" – (Appendix E), for designer's review.
j. During the construction of a project, at any time**,** if it becomes necessary to replace a minority business subcontractor, immediately advise the owner, State Construction Office, and the Director of the HUB Office in writing**,** of the circumstances involved. The prime contractor shall make a good faith effort to replace a minority business subcontractor with another minority business subcontractor.

k. If during the construction of a project additional subcontracting opportunities become available, make a good faith effort to solicit subbids from minority businesses.
l. It is the intent of these requirements apply to all contractors performing as prime contractor and first tier subcontractor under construction manager at risk on state projects.

6. Minority Business Responsibilities
While minority businesses are not required to become certified in order to participate in the State construction projects, it is recommended that they become certified and should take advantage of the appropriate technical assistance that is made available. In addition, minority businesses who are contacted by owners or bidders must respond promptly whether or not they wish to submit a bid.

SECTION 4: DISPUTE PROCEDURES
It is the policy of this state that disputes that involves a person's rights, duties or privileges, should be settled through informal procedures. To that end, minority business disputes arising under these guidelines should be resolved as governed under G.S. 143-128(g).

SECTION 5: These guidelines shall apply upon promulgation on state construction projects. Copies of these guidelines may be obtained from the Department of Administration, State Construction Office, (physical address) 301 North Wilmington Street, Suite 450, NC Education Building, Raleigh, North Carolina, 27601-2827, (mail address) 1307 Mail Service Center, Raleigh, North Carolina, 27699-1307, phone (919) 807-4100, Website: www.nc-sco.com

SECTION 6: In addition to these guidelines, there will be issued with each construction bid package provisions for contractual compliance providing minority business participation in the state construction program.

MINORITY BUSINESS CONTRACT PROVISIONS (CONSTRUCTION)

APPLICATION:

The **Guidelines for Recruitment and Selection of Minority Businesses for Participation in State Construction Contracts** are hereby made a part of these contract documents. These guidelines shall apply to all contractors regardless of ownership. Copies of these guidelines may be obtained from the Department of Administration, State Construction Office, (physical address) 301 North Wilmington Street, Suite 450, NC Education Building, Raleigh, North Carolina, 27601-2827, (mail address) 1307 Mail Service Center, Raleigh, North Carolina, 27699-1307, phone (919) 807-4100, Website: http://www.nc-sco.com

MINORITY BUSINESS SUBCONTRACT GOALS:

The goals for participation by minority firms as subcontractors on this project have been set at 10%.

The bidder must identify on its bid, the minority businesses that will be utilized on the project with corresponding total dollar value of the bid and affidavit (Affidavit A) listing good faith efforts **or** affidavit (Affidavit B) of self-performance of work, if the bidder will perform work under contract by its own workforce, as required by G.S. 143-128.2(c) and G.S. 143-128.2(f).

The lowest responsible, responsive bidder must provide Affidavit C, that includes a description of the portion of work to be executed by minority businesses, expressed as a percentage of the total contract price, which is equal to or more than the applicable goal.

OR

Provide Affidavit D, that includes a description of the portion of work to be executed by minority businesses, expressed as a percentage of the total contract price, **with documentation of Good Faith Effort, if the percentage is not equal to the applicable goal.**

OR

Provide Affidavit B, which includes sufficient information for the State to determine that the bidder does not customarily subcontract work on this type project.

The above information must be provided as required. Failure to submit these documents is grounds for rejection of the bid.

MINIMUM COMPLIANCE REQUIREMENTS:

All written statements, affidavits or intentions made by the Bidder shall become a part of the agreement between the Contractor and the State for performance of this contract. Failure to comply with any of these statements, affidavits or intentions, or with the minority business Guidelines shall constitute a breach of the contract. A finding by the State that any information submitted either prior to award of the contract or during the performance of the contract is inaccurate, false or incomplete, shall also constitute a breach of the contract. Any such breach may result in termination of the contract in accordance with the termination provisions contained in the contract. It shall be solely at the option of the State whether to terminate the contract for breach.

In determining whether a contractor has made Good Faith Efforts, the State will evaluate all efforts made by the Contractor and will determine compliance in regard to quantity, intensity, and results of these efforts. Good Faith Efforts include:

(1) Contacting minority businesses that reasonably could have been expected to submit a quote and that were known to the contractor or available on State or local government maintained lists at least 10 days before the bid or proposal date and notifying them of the nature and scope of the work to be performed.

(2) Making the construction plans, specifications and requirements available for review by prospective minority businesses, or providing these documents to them at least 10 days before the bid or proposals are due.

(3) Breaking down or combining elements of work into economically feasible units to facilitate minority participation.

(4) Working with minority trade, community, or contractor organizations identified by the Office for Historically Underutilized Businesses and included in the bid documents that provide assistance in recruitment of minority businesses.

(5) Attending any prebid meetings scheduled by the public owner.

(6) Providing assistance in getting required bonding or insurance or providing alternatives to bonding or insurance for subcontractors.

(7) Negotiating in good faith with interested minority businesses and not rejecting them as unqualified without sound reasons based on their capabilities. Any rejection of a minority business based on lack of qualification should have the reasons documented in writing.

(8) Providing assistance to an otherwise qualified minority business in need of equipment, loan capital, lines of credit, or joint pay agreements to secure loans, supplies, or letters of credit, including waiving credit that is ordinarily required. Assisting minority businesses in obtaining the same unit pricing with the bidder's suppliers in order to help minority businesses in establishing credit.

(9) Negotiating joint venture and partnership arrangements with minority businesses in order to increase opportunities for minority business participation on a public construction or repair project when possible.

(10) Providing quick pay agreements and policies to enable minority contractors and suppliers to meet cash-flow demands.

APPENDIX E

MBE DOCUMENTATION FOR CONTRACT PAYMENTS

Prime Contractor/Architect: _____

Address & Phone: _____

Project Name: _____

Pay Application #: _____ Period: _____

The following is a list of payments made to Minority Business Enterprises on this project for the above-mentioned period.

MBE FIRM NAME	* INDICATE TYPE OF MBE	AMOUNT PAID THIS MONTH	TOTAL PAYMENTS TO DATE	TOTAL AMOUNT COMMITTED

*Minority categories: Black, African American (B), Hispanic (H), Asian American (A), American Indian (I), Female (F), Social and Economically Disadvantage (D)

Date: _____ Approved/Certified By: _____
Name

_____
Title

_____
Signature

SUBMIT WITH EACH PAY REQUEST & FINAL PAYMENT

(Revised on 3/14/2003)

BID BOND

FORM OF BID BOND

KNOW ALL MEN BY THESE PRESENTS THAT _____ _____ as principal, and _____, as surety, who is duly licensed to act as surety in North Carolina, are held and firmly bound unto the State of North Carolina***** through _____ as obligee, in the penal sum of _____ DOLLARS, lawful money of the United States of America, for the payment of which, well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

Signed, sealed and dated this ____ day of ____ 20_

WHEREAS, the said principal is herewith submitting proposal for

and the principal desires to file this bid bond in lieu of making

the cash deposit as required by G.S. 143-129.

NOW, THEREFORE, THE CONDITION OF THE ABOVE OBLIGATION is such, that if the principal shall be awarded the contract for which the bid is submitted and shall execute the contract and give bond for the faithful performance thereof within ten days after the award of same to the principal, then this obligation shall be null and void; but if the principal fails to so execute such contract and give performance bond as required by G.S. 143-129, the surety shall, upon demand, forthwith pay to the obligee the amount set forth in the first paragraph hereof. Provided further, that the bid may be withdrawn as provided by G.S. 143-129.1

_____(SEAL)

_____(SEAL)

_____(SEAL)

_____(SEAL)

_____(SEAL)

CONTRACT FORMS

CONSTRUCTION CONTRACT

FORM OF CONSTRUCTION CONTRACT

(ALL PRIME CONTRACTS)

THIS AGREEMENT, made the _____ day of _____ in the year of 20__ by and between _____ _____ hereinafter called the Party of the First Part and the State of North Carolina, through the_____ _____ hereinafter called the Party of the Second Part.

WITNESSETH:

That the Party of the First Part and the Party of the Second Part for the consideration herein named agree as follows:

1. Scope of Work: The Party of the First Part shall furnish and deliver all of the materials, and perform all of the work in the manner and form as provided by the following enumerated plans, specifications and documents, which are attached hereto and made a part thereof as if fully contained herein: advertisement; Instructions to Bidders; General Conditions; Supplementary General Conditions; specifications; accepted proposal; contract; performance bond; payment bond; power of attorney; workmen's compensation; public liability; property damage and builder's risk insurance certificates; approval of attorney general; certificate by the Office of State Budget and Management, and drawings, titled:

_____

_____

_____

Consisting of the following sheets:

_____

_____

_____

_____

Dated: _____ and the following addenda:

Addendum No _____ Dated: _____ Addendum No. _____ Dated: _____

Addendum No _____ Dated: _____ Addendum No. _____ Dated: _____

Addendum No _____ Dated: _____ Addendum No. _____ Dated: _____

Addendum No _____ Dated: _____ Addendum No. _____ Dated: _____

2. That the Party of the First Part shall commence work to be performed under this agreement on a date to be specified in a written order of the Party of the Second Part and shall fully complete all work hereunder within _____ consecutive calendar days

from said date. For each day in excess thereof, liquidated damages shall be as stated in Supplementary General Conditions. The Party of the First Part, as one of the considerations for the awarding of this contract, shall furnish to the Party of the Second Part a construction schedule setting forth planned progress of the project broken down by the various divisions or part of the work and by calendar days as outlined in Article 14 of the General Conditions of the Contract.

3. The Party of the Second Part hereby agrees to pay to the Party of the First Part for the faithful performance of this agreement, subject to additions and deductions as provided in the specifications or proposal, in lawful money of the United States as follows:

_____

_____($ _____).

Summary of Contract Award:

4. In accordance with Article 31 and Article 32 of the General Conditions of the Contract, the Party of the Second Part shall review, and if approved, process the Party of the First Party's pay request within 30 days upon receipt from the Designer. The Party of the Second Part, after reviewing and approving said pay request, shall make payments to the Party of the First Part on the basis of a duly certified and approved estimate of work performed during the preceding calendar month by the First Party, less five percent (5%) of the amount of such estimate which is to be retained by the Second Party until all work has been performed strictly in accordance with this agreement and until such work has been accepted by the Second Party. The Second Party may elect to waive retainage requirements after 50 percent of the work has been satisfactorily completed on schedule as referred to in Article 31 of the General Conditions.

5. Upon submission by the First Party of evidence satisfactory to the Second Party that all payrolls, material bills and other costs incurred by the First Party in connection with the construction of the work have been paid in full, final payment on account of this agreement shall be made within thirty (30) days after the completion by the First Party of all work covered by this agreement and the acceptance of such work by the Second Party.

6. It is further mutually agreed between the parties hereto that if at any time after the execution of this agreement and the surety bonds hereto attached for its faithful performance, the Second Party shall deem the surety or sureties upon such bonds to be unsatisfactory, or if, for any reason, such bonds cease to be adequate to cover the performance of the work, the First Party shall, at its expense, within five (5) days after the receipt of notice from the Second Party so to do, furnish an additional bond or bonds in such form and amount, and with such surety or sureties as shall be satisfactory to the Second Party. In such event no further payment to the First Party shall be deemed to be due under this agreement until such new or additional security for the faithful performance of the work shall be furnished in manner and form satisfactory to the Second Party.

7. The Party of the First Part attest that it and all of its subcontractors have fully complied with all requirements of NCGS 64 Article 2 in regards to E-Verification as required by Section 2.(c) of Session Law 2013-418, codified as N.C. Gen. Stat. § 143-129(j).

IN WITNESS WHEREOF, the Parties hereto have executed this agreement on the day and date first above written in _____ counterparts, each of which shall without proof or accounting for other counterparts, be deemed an original contract.

Witness:

_____
Contractor: (Trade or Corporate Name)

_____
(Proprietorship or Partnership)

By: _____

Title: _____
(Owner, Partner, or Corp. Pres. or Vice Pres. only)

Attest: (Corporation)

By: _____

Title: _____
(Corp. Sec. or Asst. Sec. only)

The State of North Carolina through*

(CORPORATE SEAL)

_____
(Agency, Department or Institution)

Witness:

_____

By:_____

Title: _____

FORM OF PERFORMANCE BOND

Date of Contract: _____

Date of Execution: _____

Name of Principal (Contractor) _____

Name of Surety: _____

Name of Contracting Body: _____

Amount of Bond: _____

Project

KNOW ALL MEN BY THESE PRESENTS, that we, the principal and surety above named, are held and firmly bound unto the above named contracting body, hereinafter called the contracting body, in the penal sum of the amount stated above for the payment of which sum well and truly to be made, we bind, ourselves, our heirs, executors, administrators, and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that whereas the principal entered into a certain contract with the contracting body, identified as shown above and hereto attached:

NOW, THEREFORE, if the principal shall well and truly perform and fulfill all the undertakings, covenants, terms, conditions and agreements of said contract during the original term of said contract and any extensions thereof that may be granted by the contracting body, with or without notice to the surety, and during the life of any guaranty required under the contract, and shall also well and truly perform and fulfill all the undertakings, covenants, terms, conditions and agreements of any and all duly authorized modifications of said contract that may hereafter be made, notice of which modifications to the surety being hereby waived, then, this obligation to be void; otherwise to remain in full force and virtue.

IN WITNESS WHEREOF, the above-bounden parties have executed this instrument under their several seals on the date indicated above, the name and corporate seal of each corporate party being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

Executed in _____ counterparts.

Witness:

_____
(Proprietorship or Partnership)

Attest: (Corporation)

By: _____

Title: _____
(Corp. Sec. or Asst. Sec. only)

(Corporate Seal)

_____
Contractor: (Trade or Corporate Name)

By: _____

Title: _____
(Owner, Partner, or Corp. Pres. or Vice Pres. only)

_____
(Surety Company)

Witness:

_____

By: _____

Title: _____
(Attorney in Fact)

Countersigned:

_____

_____
(N.C. Licensed Resident Agent)

_____

_____
Name and Address-Surety Agency

_____

_____
Surety Company Name and N.C. Regional or Branch Office Address

(Surety Corporate Seal)

FORM OF PAYMENT BOND

Date of Contract: _____

Date of Execution: _____

Name of Principal (Contractor) _____

Name of Surety: _____

Name of Contracting Body: _____

Amount of Bond: _____

Project _____

KNOW ALL MEN BY THESE PRESENTS, that we, the principal and surety above named, are held and firmly bound unto the above named contracting body, hereinafter called the contracting body, in the penal sum of the amount stated above for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators, and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that whereas the principal entered into a certain contract with the contracting body identified as shown above and hereto attached:

NOW, THEREFORE, if the principal shall promptly make payment to all persons supplying labor/material in the prosecution of the work provided for in said contract, and any and all duly authorized modifications of said contract that may hereafter be made, notice of which modifications to the surety being hereby waived, then this obligation to be void; otherwise to remain in full force and virtue.

IN WITNESS WHEREOF, the above-bounden parties have executed this instrument under their several seals on the date indicated above, the name and corporate seal of each corporate party being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

Executed in _____ counterparts.

Witness:

_____
(Proprietorship or Partnership)

Attest: (Corporation)

By: _____

Title: _____
(Corp. Sec. or Asst. Sec.. only)

(Corporate Seal)

_____
Contractor: (Trade or Corporate Name)

By: _____

Title_____
(Owner, Partner, or Corp. Pres. or Vice Pres. only)

_____
(Surety Company)

Witness:

_____

By: _____

Title: _____
(Attorney in Fact)

Countersigned:

_____

_____
(N.C. Licensed Resident Agent)

_____

_____
Name and Address-Surety Agency

_____

_____
Surety Company Name and N.C.
Regional or Branch Office Address

(Surety Corporate Seal)

Sheet for Attaching Power of Attorney

Sheet for Attaching Insurance Certificates

APPROVAL OF THE ATTORNEY GENERAL

CERTIFICATION BY THE OFFICE OF STATE BUDGET AND MANAGEMENT

Provision for the payment of money to fall due and payable by the

_____

under this agreement has been provided for by allocation made and is available for the purpose of carrying out this agreement.

This _____day of _____ 20___.

Signed _____
Budget Officer

STATE OF NORTH CAROLINA
COUNTY SALES AND USE TAX REPORT
SUMMARY TOTALS AND CERTIFICATION

CONTRACTOR: _____ Page __1____ of _____

PROJECT: _____ FOR PERIOD: _____

	TOTAL FOR COUNTY OF:	TOTAL FOR COUNTY OF:	TOTAL FOR COUNTY OF:	TOTAL FOR COUNTY OF:	TOTAL FOR COUNTY OF:	TOTAL FOR COUNTY OF:	TOTAL ALL COUNTIES
CONTRACTOR							
SUBCONTRACTOR(S)*							
COUNTY TOTAL							

* Attach subcontractor(s) report(s)
** Must balance with Detail Sheet(s)

I certify that the above figures do not include any tax paid on supplies, tools and equipment which were used to perform this contract and only includes those building materials, supplies, fixtures and equipment which actually became a part of or annexed to the building or structure. I certify that, to the best of my knowledge, the information provided here is true, correct, and complete.

Sworn to and subscribed before me,

This the _____ day of _____, 20____

_____
Signed

_____
Notary Public

_____
Print or Type Name of Above

My Commission Expires: _____

Seal

NOTE:
This certified statement may be subject to audit.

STATE OF NORTH CAROLINA
SALES AND USE TAX REPORT DETAIL

CONTRACTOR: _____

SUBCONTRACTOR _____ FOR PERIOD: _____

PROJECT: _____

PURCHASE DATE	VENDOR NAME	INVOICE NUMBER	TYPE OF PROPERTY	INVOICE TOTAL	COUNTY TAX PAID	COUNTY OF SALE *
				$	$	
				TOTAL:	$	

* If this is an out-of-state vendor, the County of Sale should be the county to which the merchandise was shipped.

SECTION 002150 - DOCUMENT CLARIFICATION REQUEST (DCR)

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Specified This Section:
   1. This Section specifies administrative and procedural requirements for disposition of Document Clarification Request (DCRs) during the Bidding Phase.

1.2 SUBMITTALS

A. Submit each request (DCR) on the form included this in section.

B. Provide only one request on each form.

C. Email DCR form to RMF Engineering.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 CONDITIONS:

A. Submit requests to the Engineer as soon as possible.

B. DCRs will be received up to seven (7) calendar days prior to the Bid date. DCRs received after that date will not be reviewed.

3.2 ACTION:

A. The Engineer will review the information requested.
   1. If, after researching the issue, if the information is found within the Contract Documents, then no formal response will be forth coming.

B. The Engineer’s response will be in the space provided on the DCR form included this in section.

002150 – DOCUMENT CLARIFICATION REQUEST (DCR)

DOCUMENT CLARIFICATION REQUEST Date:	
Attention:	Submitted By:
RMF Engineering, Inc. 8081 Arco Corporate Dr., Suite 300 Raleigh, NC 27617	

Subject:

Specification Number:

Drawing Sheet Number:

INFORMATION REQUESTED

Signed: _____

RESPONSE

- ❑ See Drawings/Specifications_____
- ❑ See Addenda to be issued
- ❑ Other

Answered By: _____ Date: _____

END OF DOCUMENT 002150

SECTION 00938 - REQUESTS FOR INFORMATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Specified This Section:
   1. This Section specifies administrative and procedural requirements for handling requests for information (RFIs) during construction.

1.2 SUBMITTALS

A. Request For Information Submittal:
   1. Submit each request (RFI) on the attached form and in accordance with procedures stipulated below.
   2. Identify the issue, fabrication, or installation method in question in each request. Include related Specification Section and Drawing numbers. Provide complete documentation stating the issue. Include copies of Product Data, Drawings, descriptions of products, fabrication details, installation procedures or other information to help clarify the Contractor's request.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 CONDITIONS

A. Submit any such requests to the Engineer as early as possible so as to cause no delay in the progress of the Work and enough in advance to allow the Engineer reasonable and adequate time to provide a full and proper response. If the information being requested from the Engineer can be reasonably determined by existing information contained within the Contract Documents then the Contractor shall reimburse the Engineer for time spent researching the RFI at the Engineer's current hourly rate.

3.2 ENGINEER'S ACTION

A. After receipt of the request for information, the Engineer may request additional information or documentation necessary for evaluation of the request. After receipt and review of all pertinent information and documentation, the Engineer will issue his response. Such response may be in written form or drawings as the Engineer shall determine.

00938 - REQUEST FOR INFORMATION

REQUEST FOR INFORMATION Date:	
PART 4 - Attention:	Submitted By:
RMF Engineering 8081 Arco Corporate Dr., Suite 300 Raleigh, NC 27617	RFI # _____.
Subject:	
INFORMATION REQUESTED Drawing and detail reference: Specification section and paragraph:	
Signed: _____ Contractor's Authorized Representative hereby certifies that he has preplanned all Work as per General Conditions Article 3.2 and his request is being submitted as to cause no delay in the progress of the Work.	
RESPONSE	

Answered By: _____ Date: _____

END OF SECTION 009380

SECTION 011000 - SUMMARY

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 WORK COVERED BY CONTRACT DOCUMENTS

A. The Work of Project is defined by the Contract Documents and includes, but is not limited to, the following:
   1. Demolition consists of the removal of existing chiller and removal of existing roof exhaust fans along with their associated disconnect switches and power circuits; removal of the inlet guide vanes on AHU-1A & AHU-1B and other work indicated in the Contract Documents
   2. New work consists of the installation of a new air-cooled chiller and redundant chilled water pump along with reworking of the chilled water piping system; installation of new roof exhaust fans, rework of the existing duct system, and installation of new variable frequency drives and power circuits; modifications to AHU-1A & AHU-1B including new inverter-duty fan motors with variable frequency drives; installation of a new ductless-split air conditioning system in Mechanical Room 137 and other work indicated in the Contract Documents

B. Type of Contract:
   1. Project will be constructed under a single prime contract.
   2. The Owner will execute a single agreement with the successful Contractor Bidder whose work will include general construction, mechanical, electrical, and all other work required by the Contract Documents.

1.3 CONTRACTOR'S USE OF SITE AND PREMISES

A. Restricted Use of Site: Contractor shall have limited use of Project site for construction operations as indicated on Drawings by the Contract limits and as indicated by requirements of this Section.

B. Limits on Use of Site: Limit use of Project site to Work in areas indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.
   1. Driveways, Walkways and Entrances: Keep driveways, loading areas, and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or for storage of materials.

a. Schedule deliveries to minimize use of driveways and entrances by construction operations.
b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

C. Condition of Existing Building: Maintain portions of existing building affected by construction operations in a weathertight condition throughout construction period. Repair damage caused by construction operations.

D. Condition of Existing Grounds: Maintain portions of existing grounds, landscaping, and hardscaping affected by construction operations throughout construction period. Repair damage caused by construction operations.

1.4 COORDINATION WITH OCCUPANTS

A. Full Owner Occupancy: Owner will occupy Project site and building(s) during entire construction period. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's day-to-day operations. Maintain existing exits unless otherwise indicated.
1. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from Owner and approval of authorities having jurisdiction.
2. Notify Owner not less than 72 hours in advance of activities that will affect Owner's operations.

1.5 OWNER’S REQUIREMENTS

A. Interruption of Utilities: It is imperative that all utilities and all other services are maintained at all times except for scheduled interruptions. Required utility interruptions shall be scheduled and requested through the NC Department of Agriculture and Consumer Services at least fourteen (14) days in advance for minor outages and thirty (30) days in advance for major outages. The NC Department of Agriculture and Consumer Services is the sole determiner of the utility outage being major or minor. Major outages include but are not limited to those that affect an entire floor of a building, all of a building, all or parts of several buildings, all or parts of an area, and any high voltage outage. No utility outage regardless of the advance notice given shall be undertaken without expressed, specific approval from the NC Department of Agriculture and Consumer Services. If requested by the NC Department of Agriculture and Consumer Services, utility outages shall be performed after hours and/or at night, or over the weekend, or during holidays. No extra payment will be made for such work. The NC Department of Agriculture and Consumer Services personnel will perform certain activities with utility outages such as operating existing electrical switches, turning existing water and steam valves, placing existing building systems back in operation, operating existing fire alarm systems, etc. The NC Department of Agriculture and Consumer Services will bear the expense of the work of their personnel. No service disruptions shall take place until barricades

(if applicable) and signs are in place to notify or protect the public. Barricades must be maintained at all times and signs shall be neat and legible. Hand-made signs are not acceptable.

1.6 WORK RESTRICTIONS

A. Comply with restrictions on construction operations.
   1. Comply with limitations on use of public streets, work on public streets, rights of way, and other requirements of authorities having jurisdiction.

B. Noise, Vibration, Dust, and Odors: Coordinate operations that may result in high levels of noise and vibration, dust, odors, or other disruption to Owner occupancy with Owner.
   1. Notify Owner not less than fourteen days in advance of proposed disruptive operations.
   2. Obtain Owner's written permission before proceeding with disruptive operations.

C. Smoking and Controlled Substance Restrictions: Use of tobacco products**,** alcoholic beverages, and other controlled substances on Owner's property is not permitted.

D. Employee Identification: Provide identification tags for Contractor personnel working on Project site. Require personnel to use identification tags at all times.

PART 2 - \PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 011000

SECTION 012300 - ALTERNATES

PART 1 - PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included This Section:
   1. This section specifies administrative and procedural requirements for Alternates.

1.2 DEFINITION:

A. An Alternate is an amount proposed by Bidders and stated on the Bid Form for certain construction activities defined in the Bidding Requirements that may be added to or deducted from Base Bid amount if the Owner decides to accept a corresponding change in either the amount of construction to be completed, or in the products, materials, equipment, systems or installation methods described in Contract Documents.
   1. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.

1.3 COORDINATION:

A. Coordinate related Work and modify or adjust adjacent Work as necessary to ensure that Work affected by each accepted Alternate is complete and fully integrated into the project.

1.4 SCHEDULE:

A. A "Schedule of Alternates" is included at the end of this Section. Specification Sections referenced in the Schedule contain requirements necessary to achieve the Work described under each Alternate.

B. Include as part of each Alternate, miscellaneous devices, accessory objects and similar items incidental to or required for a complete installation whether or not mentioned as part of the Alternate.

PART 2 - PRODUCTS (Not Applicable).

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. Alternate 1 – Ductless Split System
   1. Provide and install a new ductless split system in Mechanical Room 137 with independent controls to be monitored by Siemens BAS.

B. Alternate 2 – Standby Chilled Water Pump
   1. Provide and install a new standby chilled water pump with automatic controls.

C. Alternate 3 – Exhaust Fan Variable Frequency Drives
   1. Provide and install variable frequency drive in lieu of combination starter/disconnect for replacement exhaust fans EF-1, EF-2, EF-4, EF-7, EF-8, EF-9, EF-10, EF-11, EF-12, EF-14.

D. Alternate 4 – AHU-1A & AHU-1B Variable Frequency Drives
   1. Remove inlet guide vanes and fan motors on AHU-1A and AHU-1B. Provide and install new inverter duty motors and variable frequency drives with duct static pressure sensors and automatic controls.

END OF SECTION 012300

SECTION 012500 - CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included in This Section:
   1. This section specifies administrative and procedural requirements for handling and processing Contract modifications.

1.2 CHANGE PROPOSAL REQUESTS (CPR)

A. Prior to incorporation in a Change Proposal Request each proposed change in the Work, adjustment to the Contract Sum, or adjustment to the Contract Time will be identified as a Change Proposal Request (CPR) each of which will be assigned a number by the Architect.

B. Change Proposal Requests are for pricing and can be used to make minor changes in the work without invalidating the Contract.

C. Proposals shall be submitted to the Architect within 10 days of receipt by the Contractor of a Change Proposal Request; shall be complete in all respects; shall show the proposed effect on both the Contract Sum and the Contract Time; and shall not be withdrawn or modified by the Contractor for 30 days following submittal. Proposals shall be based on costs necessarily incurred by the Contractor in the proper performance of the Work. Such costs shall be at rates not higher than the standard paid at the place of the Project except with prior consent of the Owner. Proposals shall include only those items set forth below:
   1. Wages of construction workers directly employed by the Contractor to perform the construction of the Work, including welfare, unemployment compensation, social security and other benefits.
   2. Costs, including transportation, of materials and equipment incorporated or to be incorporated in the completed construction. All discounts for cash or prompt payment shall accrue to the Contractor.
   3. Payments made by the Contractor to Subcontractors in accordance with the requirements of the subcontracts.
   4. Cost of all materials, temporary facilities, equipment and hand tools not customarily owned by the construction workers, which are provided by the Contractor at the site and fully consumed in the performance of the Work.
   5. Reasonable rental costs for necessary temporary facilities, machinery, equipment, and hand tools used at the site of the Work, whether rented from the Contractor or others. Rates and quantities of equipment rented shall be subject to the Owner's prior approval. That portion directly attributable to this Contract of premiums for performance bonds.

6. Losses and expenses not compensated by insurance or otherwise, sustained by the Contractor in connection with the Work, provided they have resulted from causes other than the fault or neglect of the Contractor.
7. Costs of removal of debris from the site.
8. Costs incurred in taking action to prevent threatened damage, injury or loss in case of an emergency affecting the safety of persons and property.
9. Other costs incurred in the performance of the Work if and to the extent approved in advance in writing by the Owner.

D. Proposals shall not include:
1. Salaries and other compensation of the Contractor's personnel stationed at the Contractor's principal office or offices.
2. Expenses of the Contractor's principal office and offices other than the site office.
3. Overhead and general expenses.
4. The Contractor's capital expenses, including interest on the Contractor's capital employed for the Work.
5. Rental costs of machinery and equipment, except as specifically provided in allowance for overhead and profit scheduled below.
6. Costs due to the fault or negligence of the Contractor, Subcontractors, anyone directly or indirectly employed by any of them, or for whose acts any of them may be liable, including, but not limited to, costs for the correction of damaged, defective or nonconforming Work, disposal and replacement of materials and equipment incorrectly ordered or supplied, and making good damage to property not forming part of the Work.
7. Any cost not specifically and expressly described in items 1 through 6 above.

1.3 CHANGE PROPOSAL REQUEST PROCEDURES

A. Upon approval and execution by the Owner of a Change Proposal Request (CPR) and the Contractor's associated proposal the Contractor shall promptly proceed with the change in the Work involved. An approved Change Proposal Request (CPR) and the Contractor's associated proposal shall be considered the full amount of compensation, or credit, for the work involved, omitted, or substituted and no additional claims may be made regarding this item.

B. At the time of signing a Change Proposal Request, the Contractor shall notify his Surety that the Contract Sum has been changed by the amount of this Change Proposal Request and he shall furnish his Surety with a copy of the approved Change Proposal Request.

C. Change Proposal Request Format:
1. Use the format included at the end of this Section for submittal of CPR's .

PART 2 - PART 2 - PRODUCTS (Not Applicable).

PART 3 - PART 3 - EXECUTION (Not Applicable).

SEE FORMAT NEXT PAGE

CHANGE PROPOSAL REQUEST SUMMARY

(a)	Materials (Provide itemized breakdown)	$ _____	
(b)	Rent of Equipment (list Separately) At rates not in excess of those prevailing in locality of the project.	$ _____	
	Sub-Total (1) [a + b]		$ _____
(c)	Overhead & Profit (10% x Subtotal (1) for additive changes, 0% for deductive changes.)	$ _____	
	Sub-Total (2) [Subtotal 1 + c]		$ _____
(d)	Labor (Provide itemized breakdown)	$ _____	
(e)	Overhead & Profit (10% x Labor item (d) for additive changes, 0% for deductive changes.)	$ _____	
	Sub-Total (3) [d + e]		$ _____
(f)	Sub-Contract Work (if applicable, same breakdown as shown above.)	$ _____	
(g)	Contractor's Overhead and Profit on Sub-Cost (5% for additive changes, 0% for deductive changes.)	$ _____	
	Sub-Total (4) [f + g]		$ _____
(h)	Insurance (Workmen's Compensation, Social Security or as otherwise required and/or specified.)	$ _____	
	Sub-Total (5) [Based on d]		$ _____
(i)	Guarantee Bond (on Sub-Total (2) + Sub-Total (3) or Sub-Total 4 as applicable)		$ _____
	Total		$ _____

Extension of Time Requested: _____ calendar days.*

* Attach detailed justification.

END OF SECTION 012500

SECTION 012900 - APPLICATIONS FOR PAYMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Work Specified In This Section
   1. This Section specifies administrative and procedural requirements governing the Contractor's Applications for Payment.

1.2 SCHEDULE OF VALUES

A. The Schedule of Values shall be submitted on AIA-G702 and G703 forms and shall be in sufficient detail to show the work of each section of the Specifications and each line item shall further include a separate listing for Total Cost of Labor and Total Cost for Materials and Equipment.

B. The Contractor(s) shall submit such data as may be required by the Architect to establish the reasonableness of the value assigned to the labor and/or materials for each line item.

C. The following minimum items in addition to the above shall be required:
   1. Pre-construction Cost:
      a. Building permits and fees.
      b. Bonds
      c. Mobilization.
   2. On site General Conditions:
      a. Job Site Superintendent and supervisory staff.
      b. Office and Storage Trailers.
      c. Utilities.
      d. Clean-up, dumpster, etc.
   3. Project Close Out Requirements.
   4. Home Office Overhead and Profit.

D. In phased projects, the Schedule of Values shall be so arranged that each phase of the project is scheduled separately with line items for each of the various portions of the Work which constitute that phase. For each item, the Schedule of Values shall show separate line items for labor and materials. Along with separate line items for labor and materials; provide line items per each floor of each phase as directed by the Architect.

E. At the time of submitting the Schedule of Values, the Contractor shall also submit an estimate of the amount of each Request for Payment for the Owner's use in planning cash flow for the Project. It is understood that actual amounts requested by the Requests for Payment may not agree with this estimate.

1.3 APPLICATIONS FOR PAYMENT

A. The Contractor shall provide to the Architect one Electronic PDF copy of the Pay Application; assembled and indexed with all required items indicated within this section.

B. Unless otherwise agreed between the Owner and Contractor, the Contractor shall submit his requests for payment not later than the twenty-fifth day of each month. Requests shall be based on work performed during the period ending with the date of the request.

C. The Owner will make a partial payment to the Contractor based on Contractor's requests duly certified, notarized and approved by the Architect by the twenty-fifth of the following month.

D. Until Substantial Completion, the Owner will pay ninety percent (90%) of the amount due the Contractor on account of progress payments.

E. Upon Substantial Completion the Owner will continue to hold full amount of retainage until the Contractor achieves final completion.

F. Each Request for Payment shall be accompanied by:
   1. Written consent of the Contractor's Surety.
   2. Such consent shall state that Surety agrees to payment of the sum requested, that the value of the work stated in the Contractor's request is a true statement, and that the sums requested for stored materials (if any) are correct.
   3. Provide Pay Application Summary Sheet (section 01291).
   4. Provide Certified Sales Tax Report. (section 01291).
   5. Coordination Drawings shall be submitted by the second Application for Payment. (if applicable to project).
   6. A monthly up-dated schedule signed by general contractor.
   7. Lien waivers.
   8. Previous Month’s Project Monitoring Log.
   9. Proof of Payment Certification form (in accordance with section 00102).

1.4 STORED MATERIALS

A. In requesting payment for materials stored on or off the site, the Contractor shall submit with his Application for Payment the following:
   1. An itemized list of the stored material prepared in sufficient detail to identify the materials and their value.
   2. Evidence such as bills of sale or such other proof as may be requested by the Owner or Architect to substantiate that the materials listed have been paid for by the Contractor, or for materials stored at the site only, a notarized statement from the materials supplier stating that the materials will become the property of the Owner upon payment by the Owner to the Contractor.
   3. In addition for material stored off the site, the Contractor shall submit with his Application for Payment the following:

a. Evidence that the materials are stored at the location previously agreed to in writing as provided by Subparagraph 9.3.2 of the General Conditions. No payment will be made for material stored off the site until the storage location has been agreed upon in writing.
b. Evidence that the storage location is bonded.
c. Evidence that the materials are insured while in storage and while in transit to the site.
d. Evidence that transportation to the site will be provided.

4. The materials may be reviewed in their storage location by the Architect. This review, if performed, is an extra service for which the Owner shall pay the Architect and for which the Owner shall be reimbursed by the Contractor by Change Order.

1.5 PROGRESS PAYMENTS

A. Provide with each Application for Payment, notarized waivers of lien from all subcontractors and material suppliers and if requested by the Owner:
1. the Contractor's sworn statement showing names and addresses of all subcontractors furnishing materials or labor and the amounts due or to become due each;
2. the Contractor's sworn statement showing the names and addresses of all material suppliers furnishing materials or labor and the amounts due or to become due or to become due each; and
3. a sworn statement from each subcontractor showing names and addresses of all persons furnishing materials or labor and the amounts due or to become due each.

1.6 FINAL PAYMENT

A. At the completion of the Project prior to receiving final payment, the Contractor shall furnish the Owner, through the Architect, properly signed and notarized waivers of lien from all subcontractors employed and material suppliers furnishing materials for the Project. Such waivers shall be submitted before final payment will be processed to the Owner by the Architect.

B. Administrative actions and submittals that shall proceed or coincide with this application include:
1. Notarized final waiver of lien.
2. Occupancy permits and similar approvals.
3. Warranties (guarantees) and maintenance agreements.
4. Final test/adjust/balance records.
5. Final medical gas certificates
6. Maintenance instructions.
7. Start-up performance reports.
8. Final cleaning.
9. Consent of Surety.
10. Verification of continued insurance.
11. Completion of Project closeout requirements.

12. Completion of items specified for completion after Substantial Completion.
13. Assurance that unsettled claims will be settled prior to payment.
14. Assurance that Work not complete and accepted will be completed without delay.
15. Transmittal of required Project construction records to Owner.
16. Certified property survey (if required).
17. Proof that taxes, fees and similar obligations have been paid.
18. Removal of temporary facilities and services.
19. Final clean-up of temporary lay down area.
20. Removal of surplus materials, rubbish and similar elements.
21. Change of door locks to Owner's access.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 012900

SECTION 013100 - PROJECT COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Specified in This Section:
   1. This Section specifies administrative and supervisory requirements necessary for Project coordination including, but not necessarily limited to:
      a. Coordination.
      b. Administrative and supervisory personnel.

1.2 COORDINATION

A. The Contractor shall:
   1. Schedule the work of all sub-contractors; maintain a progress schedule for all sub-contractors for this project; notify the Architect of any changes in the progress schedule; and be responsible for providing adequate notice to all sub-contractors to insure efficient continuity of all phases of the project work.
   2. Hold meetings with the various major sub-contractors as required to coordinate work and provide work progress reports.
   3. The Contractor shall provide for scheduling of all testing as required by this contract. Such testing for each item shall be indicated on the construction schedule.
   4. The Contractor shall coordinate the securing of all final certificates of inspection, the Certificate of Occupancy, and other inspections that may be required by authorities having jurisdiction over the Work. He shall deliver same to the Architect upon completion of the Work.

1.3 COORDINATION DRAWINGS:

A. Coordination Drawings shall be prepared, and submitted to the Architect, indicating structural steel and other miscellaneous steel, General, HVAC, Plumbing, Fire Protection, and Electrical work which must be carefully coordinated by all trades to minimize space conflicts. These drawings shall be prepared prior to any trade starting work, which is in close proximity to work of any other trade(s).

B. ONLY the Architect’s electronic files of the base floor plans and the base reflected ceiling plans will be available to the Contractor for the preparation of the coordination drawings.

C. Additional coordination drawings as required by other specification sections shall be prepared by the Contractor and reviewed as required.

D. The Contractor shall be responsible for the preparation and submission of the coordination drawings. Specific efforts required by the Contractor include:
   1. Initiation of the drawings including furnishing of reproducible sheets which show Floor Plans with structural components, miscellaneous steel and reflected ceiling heights and elements.
   2. Coordination/communication with other trades during the preparation of the coordination drawings.
   3. Minimizing future conflicts between trades.

E. Each Trade Contractor shall be responsible for showing the elements of their work on the coordination drawings. Each Trade Contractor is only responsible for showing elements relative to his work and the overall coordination of the production of the coordination drawings and resolution of conflicts. These coordination drawings shall represent a collective effort by all Trade Contractors to avoid space conflicts and expedite the work of all trades. Work shall not proceed until the coordination drawings have been submitted to Architect.

F. Sequence of production of the coordination drawings shall be as follows:
   1. General work (structural components, ceiling heights, walls and soffits etc.).
   2. Electrical fixtures.
   3. HVAC work.
   4. Plumbing work.
   5. Fire Protection work.
   6. Electrical conduit
   7. General work (other than #1 above).

G. Prepare coordination drawings to a scale of 1/4" =1'0" or larger; detailing major elements, components, and systems of HVAC, plumbing, fire protection and electrical equipment and materials in relationship with other systems, installations, building structural steel and components. Dimension elements and components of the systems from column lines and indicate elevations of elements and components relative to the finished floor. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the work. General trade to indicate location of all walls (rated and non-rated), blocking locations, and all recessed wall items, etc. At minimum, the coordination drawings shall include (but not necessarily be limited to) the following:
   1. All structural and miscellaneous steel.
   2. Indicate the proposed location of all ductwork and air distribution equipment including terminal units and diffusers.
   3. Indicate the proposed location of piping services including:
      a. Domestic hot and cold water piping.
      b. Waste and vent piping.
      c. Roof drain/rain leader piping.
      d. Medical gas piping.
      e. Sprinkler piping and sprinkler heads.
   4. Indicate the proposed location of electrical conduits and all light fixtures.
   5. Indicate clearances for installing and maintaining insulation.

6. Indicate clearances for servicing and maintaining equipment, filter removal, and space for equipment disassembly required for periodic maintenance.
7. Indicate major equipment, equipment support details, and connections.
8. Indicate sizes and locations of required concrete housekeeping pads and bases.
9. Indicate all fire-rated walls and partitions.
10. Indicate location of all recessed wall items, i.e. toilet accessories, fire extinguisher cabinets, etc.
11. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
12. Prepare separate floor plans, sections, and details as required to indicate all piping and conduits routed through wood truss openings.
13. Prepare separate reflected ceiling plans to coordinate and integrate installations of air outlets and inlets, light fixtures, communication systems components, sprinkler heads, and other ceiling-mounted items.
14. It is not required (unless otherwise noted above) to indicate conduit 1-1/4" in diameter and smaller on the coordination drawings. However, the respective trade installing such elements assumes responsibility for coordinating and installing said elements in a manner that does not conflict with other elements shown on the coordination drawings.

H. Upon completion of the coordination drawings, the Contractors and major Subcontractor shall be required to sign each sheet of the coordination drawings. Signature shall attest to a diligent review and agreement to alleviate future space conflicts at no cost to the Owner. If any Trade Contractor installs elements of his work in locations other than those indicated on the coordination drawings which impacts the work of other Trade Contractors, or installs elements of his work which are not shown on the coordination drawings which impacts the work of other Trade Contractors whose elements are shown on the coordination drawings, the Trade Contractor in violation of the coordination drawings shall be required to either:
1. Move his work to resolve the conflict, or
2. Reimburse the affected Contractor to move his work to resolve the conflict, or
3. Reimburse the Owner to move his work to resolve the conflict.

I. Drawings must be complete and submitted to the Architect within 90 days after award of contract for record only. The third Application for Payment will not be processed until the coordination drawings are received by the Architect. No review or approval will be forthcoming. Coordination drawings are required for the benefit of all Trade Contractors as an aid to coordination of their work so as to eliminate or reduce conflicts that may arise during the installation of their work.

J. Coordination drawings shall be revised and re-coordinated by all trades for any major CPR which causes a change to the reflected ceiling plan or changes to ductwork, piping, fire protection or electrical drawings. The cost of these revisions is to be included as a line item in the CPR pricing.

1.4 ADMINISTRATIVE AND SUPERVISORY PERSONNEL

A. General:
1. The Contractor shall appoint a single representative, i.e. Project Manager, to be the single contact person with the Owner and/or Architect. The Project Manager shall have experience on at least two projects of similar scope, size and complexity.
2. The Contractor shall be responsible for supervising and expediting the project work with a full time on-site job superintendent. Said individual shall be on-site at all times when work is in progress. Said individual shall be a full time employee of the Contractor, not a subcontract consultant, neither consultant nor contract employee.
3. In addition to the Project superintendent, the Contractor shall give his superintendent enough support staff that his ongoing presence can be maintained on site so that errands to secure materials etc. will be carried out by others and others will receive deliveries to site.

PART 2 - PART 2 - PRODUCTS (Not Applicable).

PART 3 - PART 3 - EXECUTION (Not Applicable).

END OF SECTION 013100

SECTION 013150 - PROJECT MEETINGS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included This Section:
   1. This Section specifies administrative and procedural requirements for project meetings including but not limited to:
      a. Pre-Construction Conference.
      b. Coordination Meetings.
      c. Progress Meetings.

1.2 PRE-CONSTRUCTION CONFERENCE

A. A pre-construction conference shall be scheduled by the Engineer and held at the Project site or other convenient location after execution of the Agreement or Notice To Proceed, whichever comes first and prior to commencement of construction activities.

A. Attendees:
   1. The Owner, Engineer, the Contractor(s) and its superintendent(s) shall each be represented at the conference by persons authorized to conclude matters relating to the Work.

B. Agenda:
   1. Discuss items of significance that could affect progress including such topics as:
      a. Work sequencing.
      b. Tentative construction schedule.
      c. Designation of responsible personnel.
      d. Procedures for processing Change Proposal Requests and Change orders.
      e. Procedures for processing Applications for Payment.
      f. Submittal of Shop Drawings, Product Data and Samples.
      g. Preparation of record documents.
      h. Use of the premises.
      i. Staging areas.
      j. Security.
      k. Housekeeping.

1.3 COORDINATION MEETINGS

A. The General Contractor shall conduct project coordination meetings at regularly scheduled times convenient for all parties involved. Project coordination meetings are in addition to

specific meetings held for other purposes, such as regular progress meetings and special Pre-installation meetings.

B. Record meeting results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from each meeting, such as the Owner and Engineer.

C. Weekly Progress Meetings:
   1. To enable orderly review of progress during construction and to provide for systematic discussion of problems, weekly project meetings shall be held throughout the construction period.
   2. Persons designated by each Subcontractor shall attend and participate in weekly project meetings shall have all required authority to commit the Contractor or Subcontractor to decisions agreed upon in the project meetings.
   3. The General Contractor shall conduct the meetings, compile minutes of each meeting and will distribute copies to the Owner and the Engineer. The General Contractor shall distribute such other copies as he wishes. Each Contractor shall, to the maximum extent practicable, assign the same person or persons to represent the Contractor or Subcontractor at project meetings throughout the construction period.

D. Owner, Architect, Contractor (OAC) Project Meetings:
   1. To enable orderly review of progress during construction and to provide for systematic discussion of problems, project meetings shall be held throughout the construction period at intervals determined prior to construction.
   2. The General Contractor shall attend and participate in the OAC project meetings and shall have all required authority to commit the Contractor and Subcontractor(s) to decisions agreed upon in the project meetings.
   3. The Engineer will conduct the OAC meetings and compile minutes of each meeting and will distribute copies to the Owner and Contractor. The Contractor shall distribute such other copies as required. The General Contractor shall, to the maximum extent practicable, assign the same person or persons to represent the Contractor at project meetings throughout the construction period.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - PART 3 - EXECUTION (Not Applicable)

END OF SECTION 013150

SECTION 013250 - PROGRESS SCHEDULES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Specified In This Section:
   1. This Section specifies administrative and procedural requirements for the progress schedules and reporting progress of the Work.
   2. Refer to General Conditions and the Agreement, for definitions and specific dates of Contract Time.

1.2 QUALITY ASSURANCE

A. General:
   1. The General Contractor shall provide the progress scheduling services, including planning, evaluating and reporting.
   2. The Contractor shall deliver the construction schedule to the Owner/Architect at the Pre-Construction Meeting.
   3. No later than 5 days following the Pre-Construction meeting, the completed Construction Progress Schedule, bearing the approval signature of the Contractor, shall be submitted to the Owner and Architect.

1.3 PROGRESS SCHEDULE

A. CPM Schedule:
   1. Immediately following Contract Award, the General Contractor shall hold a meeting with the construction team for the purpose of establishing and preparing a Construction Progress Schedule.
      a. Each major subcontractor shall be represented.
   2. The Contractor shall develop a schedule demonstrating fulfillment of the contract requirements, shall keep the network up-to-date in accordance with the requirements of the contract and shall utilize the plan for scheduling, coordinating and monitoring work under this contract (including all activities of Prime contractors, subcontractors, equipment vendors and suppliers).
   3. Conventional Critical Path Method (CPM) Precedence Diagramming Method (PDM) technique will be utilized to satisfy time applications.
   4. The Construction Progress Schedule, utilizing a critical path method of scheduling, shall be detailed to a degree, which will permit proper and complete coordination of all trades in each portion of the work.

B. Network Diagram Requirements:

C.

1. Show on the network diagram the sequence and interdependence of work activities/events required for complete performance of all items of work.
2. In preparing the network diagram, the Contractor shall:
   a. Exercise sufficient care to produce a clear, legible and accurate network diagram.
3. Show the following on each work activity/event:
   a. Activity/Event ID numbers.
   b. Concise description of the work represented by the activity/event.
   c. Duration (in work days.)
   d. Manpower required (average number of men per day if requested).
   e. Indicate predecessor in column format.
4. Show activities/events as:
   a. Contractor's time required for submittal of shop drawings.
   b. Architect-Engineer's review and approval of shop drawings.
   c. Delivery of Owner furnished equipment, project phasing, Authority Having Jurisdiction inspections, and any other specification requirements.
5. Test, balance and adjust various systems and pieces of equipment.
6. Therefore, the schedule shall specifically indicate the following dates:
   a. List of testing requirements for all Specification Sections required by the Contractor’s CQC Plan.
   b. The date of satisfactory enclosure.
   c. Dates scheduled for delivery of major items of equipment.
   d. Dates scheduled for completion of installation of major items of equipment.
   e. The anticipated date of Substantial Completion for each phase of construction and local and state Authority Having Jurisdiction inspections per phase.
      Owner Training.
   f. Dates scheduled for owner occupancy of completed phased areas and dates for moving of owner’s equipment into said areas.
   g. Project closeout, as established by the Contract.
   h. The date of Final Completion of the project, as established by the Contract.
7. Submit the following supporting data in addition to the network diagram:
   a. The proposed number of working days per week.
   b. The Owner’s holidays to be observed during the life of the contract (by day, month, and year).
   c. The planned number of shifts per day (if requested).
   d. The number of hours per shift (if requested).

D. Post original and current copy of the schedule in the Project Coordinator’s field office.

E. Phasing:
1. Provide notations on the schedule to show how the sequence of the Work is affected by requirements for phased completion to permit Work by Contractor and partial occupancy by the Owner prior to Substantial Completion.

F. Schedule Updating:

1. Updated project schedule will be presented at the OAC meeting. Data dates should be no later than 5 days prior to the OAC meeting.
2. Issue the updated schedule concurrently with report of each meeting.
3. Updated schedule shall include the original baseline task bar with date and current task bar with date. All schedule updates shall indicate predecessors in column format. The schedule update shall include the data date.

G. Format:
1. Display the full network on stable transparency, or other reproducible media, of sufficient width to show data clearly for the entire construction period.
   a. Provide three (3) complete color schedules to the Architect.
   b. Provide complete color schedule in the Project Coordinator's trailer.
2. Construction Schedule shall indicate the baseline schedule.
3. Mark the critical path in red.
4. Locate the critical path near the center of the network
5. Sub networks on separate sheets are permissible for activities clearly off the critical path.

H. At the time of submitting the Construction Progress Schedule to the Architect, the Contractor shall also submit the anticipated amount of each monthly payment that will become due in accordance with the Progress Schedule(if requested).
1. When the Contractor fails or refuses to furnish formation and the associated updated schedule data, which, in the sole judgment of the Owner and Architect, is necessary for processing the monthly progress payment, the Contractor shall not be deemed to have provided supporting schedule data upon which progress payment may be made.

1.4 PROGRESS REPORTING

A. Job progress will be reviewed to verify:
1. Actual start and/or finish dates for updated/completed activities/events.
2. Remaining duration, required to complete each activity/event started, or scheduled to start, but not completed.
3. Logic, time, and approved CPR's with time for change orders, and supplemental agreements that are to be incorporated into the network diagram and computer-produced schedules.
4. Percentage for completed and partially completed activities/events.
5. Activity/event duration and percent complete shall be updated independently.

1.5 RESPONSIBILITY FOR COMPLETION

A. Whenever it becomes apparent from the current monthly progress review meeting that phasing or contract completion dates will not be met, the Contractor(s) shall execute some or all of the remedial actions stipulated in the General Conditions, Section 00797.

B. CPM revisions made under this paragraph which affect the previously approved computer-produced schedules for Owner furnished equipment, must be furnished in writing to the Owner for approval.
   1. Any service charges, i.e. additional fees associated with the revisions including storage, redelivery fees, etc. shall be the responsibility of the contractor.

1.6 ADJUSTMENT OF CONTRACT COMPLETION

A. Request for an extension of the contract completion date by the Contractor(s) shall be supported with a justification, CPM data and supporting evidence.

B. Actual delays in activities/events which, according to the computer-produced calendar-dated schedule, do not affect the extended and predicted contract completion dates shown by the critical path in the network, will not be the basis for a change to the contract completion date.

1.7 OWNER'S HOLIDAYS

A. The following Holidays are to be considered non-working days and should be reflected as such in the Contractor's Construction Schedule:
   1. New Year's Day
   2. Martin Luther King Jr's Birthday
   3. Easter (Good Friday)
   4. Memorial Day
   5. Independence Day
   6. Labor Day
   7. Thanksgiving Day
   8. Christmas Eve and Christmas Day

B. Unless noted otherwise, work hours shall be 7:00 am through 5:00 pm, Monday through Friday. No work shall be scheduled outside of these times or during weekends unless approved in advance by the Owner.

PART 2 - PRODUCTS (Not Applicable).

PART 3 - EXECUTION (Not Applicable).

END OF SECTION 013250

SECTION 013300 - SUBMITTALS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included This Section:
   1. This Section specifies administrative and procedural requirements for submittals required for performance of the Work, including;
      a. Submittal schedule.
      b. Shop Drawings.
      c. Product Data.
      d. Samples.

B. Administrative Submittals:
   1. Refer to Division-1 and other Contract Documents for requirements for administrative submittals. Such submittals include, but are not limited to:
      a. Permits.
      b. Applications for payment.
      c. Performance and payment bonds.
      d. Insurance certificates.

1.2 SUBMITTAL PROCEDURES

A. Submittal Preparation:
   1. Place a permanent label or title block on each submittal for identification. Indicate the name of the entity that prepared each submittal on the label or title block.
   2. Include the following information on the label for processing and recording action taken:
      a. Project name and Engineer's project number.
      b. Date.
      c. Name and address of Engineer.
      d. Name and address of Contractor.
      e. Name, phone number and address of subcontractor.
      f. Name, phone number and address of supplier.
      g. Name, phone number of manufacturer and his representative.
      h. Number and title of appropriate Specification Section.
      i. Drawing number and detail references, as appropriate.
   3. As a result of the Contractor's review, the Contractor shall indicate that the result of his review was:
      a. "Reviewed and Approved"
      b. "Reviewed – Approved As Noted" Prior to submission to the Engineer.

4. If appropriate, and/or permitted by the Contract Documents, the Contractor may stamp the Drawings or Submittal information "Received for Record Purposes Only", if no review of the material, by the Contractor, is required by the Contract Documents.
5. Provide a space approximately 4" x 5" on the label or beside the title block on Shop Drawings to record the Contractor's review and approval markings and the action taken.
6. Provide shop drawings or submittal information individually. Do not group like trades into one submittal binder.

B. Identification Number:
1. Each Submittal shall be numbered to comply with the following *example*:
   a. The numbering system will use the specification section as the initial submittal number, i.e. for items required in Section 06190 – Wood Trusses – the submittal will be "06190.01". The "01" identifies the submittal as the first, or submittal number one (1) under that specification section. If additional submittals are required under Section 06190, then the second submittal will be identified as "06190.02", in sequence. In the event a submittal is returned (example above – 06190.02) to the Contractor, and is marked either "Reviewed and Disapproved" or "Reviewed – Revise and Resubmit", then, the revised submittal will be identified as 06190.02.A, with the suffix "A" indicating the first resubmittal of this item, and using, progressive letters in the event of multiple re-submittals.

C. Submittal Review by Contractor:
1. The Contractor is required to review each submittal, including, but not limited to, shop drawings, product data, samples, cut sheets and similar submittals.
2. Submittals on items, materials, installations, products or vendors that are not specified or indicated on the drawings will be considered substitutions, and as such, must comply with provisions of Section 016310 – Product Substitutions, of this Project Manual.
3. Following the Contractor review of the submittal, the Contractor will place a "review stamp" on each copy of each submittal, and sign, date and indicate action taken in conformance with the "Submittal Preparation" sub-section of this Section. The same information indicated on the Contractor's review stamp will also be indicated on the "Submittal Transmittal" form included with this Section.
4. By approving and submitting Shop Drawings, Product Data, Samples and similar submittals, the Contractor represents that he has determined, or will do so, the suitability of materials, field measurements and field construction and criteria related thereto, and has checked and coordinated the information contained within such submittals, with the requirements of the Work and the Contract Documents.
5. The responsibility for coordinating the Shop Drawings, including technical data, capability (warranted and implied), sizing, color, texture, etc. shall be the sole responsibility of the Contractor. The coordination between subcontractor and/or materials supplier shall be the responsibility of each Contractor/Prime Contractor. The Project Coordinator, as defined in the Specifications, shall be responsible to supervise this activity.
6. Submittals that do not comply with provisions of this sub-section will be returned not reviewed, not logged and will be considered non-responsive.

D. Partial Submittals:
1. Partial or incomplete submittals are not acceptable. Any submittal or shop drawing received by the Engineer, that does not contain all portions required by each Section of the Specification, will be returned not reviewed, not logged and will be considered non-responsive.
2. Exceptions will be considered on a case by case basis, such as duct drawings and structural steel drawings on multi-level, multi phased or multi-zone projects. Requests for exceptions must be submitted in writing by the Contractor for evaluation and response, a minimum of 30 days prior to the submittal date indicated on the Contractor's approved/updated Submittal Schedule.

E. Submittal Review by Engineer:
1. The Engineer will review each of the Contractor's submittals one initial time, and, should re-submittal be required, one additional time to verify that the reason(s) for re-submittal have been addressed by the Contractor and corrections made. Any review required by the Engineer, other than the two (2) indicated above, will be considered additional scope of work for the Engineer, and the Contractor shall reimburse the Owner for all costs incurred, including the cost of the Engineer's services, made necessary to review such additional re-submittals.

1.3 SUBMITTAL SCHEDULE

A. Shop Drawings:
1. The Contractor shall prepare and submit to the Engineer, not later than 30 days following the Date of Commencement, and prior to the Contractor's first Application for Payment, a schedule of all Shop Drawings and Submittals as required by the Contract Documents. No Applications for Payment will be reviewed or approved until receipt and approval of the Submittal Schedule.
2. Schedule shall indicate dates for submission. The Contractor is required to submit a monthly updated submittal schedule with each Application for Payment. Pay applications received without the Submittal Schedule update will not be reviewed and will be returned to the Contractor.
3. All Shop Drawings, Samples and Submittals for approval shall be completed within sixty (60) calendar days following the Date of Commencement.
4. Coordinate the Schedule with the schedule of the individual subcontractors, suppliers or vendors, and the Contractor's Construction Schedule.
5. The Engineer will schedule his manpower to review submittals based on the time limits established above. Submittals by the Contractor received beyond the time limit established above may affect the Engineers manpower schedule resulting in additional cost; the Contractor shall reimburse the Owner for the costs of the Engineer's services for the review or approval beyond the time stipulated above.

1.4 SHOP DRAWINGS

A. General:

1. All submittals shall be dated and shall contain the project name; description or names of equipment; materials or equipment which are to be installed, reference to the Section of Specifications where it is specified and Drawing number where shown.
2. The use of Contract Documents for submittal of shop drawing is prohibited.

B. Shop Drawings:
1. Submit legible, unfolded, double-coated, reproducible transparencies (positive side up sepia) of each drawing. Each drawing shall have a clear space for stamps per requirement of the Submittal Preparation above.
2. When phrase "by others" appears on Shop Drawings, the Contractor shall indicate on drawing whom is to furnish material or operations so marked before submittal.
3. When Shop Drawings are marked after review by the Engineer, with any variation of the wording “resubmit”, or words of like meaning, the Contractor shall correct the original tracing and submit a new transparency for approval, to the Engineer. After the Engineer completes a review of each Shop Drawings transparency, the Engineer will return only the marked up or reviewed transparency to the Contractor. Additional prints required by the Contractor for further or other use(s), other trades, suppliers, vendors, shall be provided by the Contractor as required.
4. Electronic copies of the Contract Document, for use in preparing Coordination Drawings, may be furnished by the Engineer only after:
    a. The Contractor submits a request for same in writing to the Owner.
    b. The Owner forwards, to the Engineer, a copy of the Contractor’s request, together with a signed “Electronic Data Transfer Letter Agreement” which will indicate the Owner’s approval of the Contractor’s request for electronic copies of the Contract Documents.
    c. Contractor’s written agreement to pay for an Engineer’s “Change in Services” which will permit additional fee to the Engineer for services connected with the furnishing of Electronic Data to the Contractor.

C. Sheet Size:
1. Submit Shop Drawings on sheets 30" x 42".

1.5 MANUFACTURER'S LITERATURE

A. For standard manufactured items not requiring special shop drawings for manufacture, submit sufficient copies of manufacturer's catalog sheets to permit the Engineer to retain one copy, provide one copy for the Owner, and to return adequate copies for the Contractors use and distribution. Catalog cuts shall be of item to be furnished, showing scale details, sizes, dimensions, performance characteristics, capacities, wiring diagrams and controls, and all other pertinent information necessary for a review by the Engineer.

1.6 MATERIAL SAFETY AND DATA SHEETS (MSDS)

A. Provide MSDS sheets as follows:
1. One set to keep on site at all times

2. One set to be submitted for final close-out documents. See Section 01781 - Project closeout for more information.
3. Do not forward MSDS to the Engineer for Review or distribution.

1.7 SAMPLES

A. Unless otherwise specifically directed by the Engineer, all Samples shall be of the precise article proposed to be furnished by the Contractor.

B. Where variation in color, pattern, texture or other characteristics are inherent in the material or product represented, submit multiple units (not less than 3), that show approximate limits of the variations.

C. Refer to Specifications for requirements for Samples that illustrate workmanship, fabrication techniques and details of assembly, connections, operation and similar construction characteristics.

D. Submit all Samples in the quantity that is required to be returned plus one which will be retained by the Engineer.

PART 2 - PRODUCTS (Not Applicable).

PART 3 - EXECUTION (Not Applicable).

END OF SECTION 013300

SECTION 014210 - DEFINITIONS

PART 1 - GENERAL

1.1 DEFINITIONS

A. General:
   1. Definitions contained in this Section are in addition to those included in the Conditions of the Contract.

B. Indicated:
   1. The term "indicated" refers to graphic representations, notes or schedules on the Drawings, or other Paragraphs or Schedules in the Specifications, and similar requirements in the Contract Documents.
   2. Where terms such as "shown," "noted," "scheduled," and "specified" are used, it is to help the reader locate the reference; no limitation on location is intended.

C. Directed:
   1. Terms such as "directed," "requested," "authorized," "selected," "approved," "required," and "permitted" mean "directed by the Engineer," "requested by the Engineer", and similar phrases.

D. Approve:
   1. The term "approve" and "approved," where used in conjunction with the Engineer's action on the Contractor's submittals, applications, and requests, is limited to the Engineer's duties and responsibilities as stated in the Conditions of the Contract.

E. Satisfactory:
   1. The words "satisfactory", submitted", "reported", and similar words and phrases shall be presumed to be followed by "to the Engineer."

F. Equal To:
   1. "Equal To", "Or Engineer Approved Equal", and "Or Approved Equal" shall mean products by manufacturers other than those described or listed in the Contract Documents which the Contractor has submitted for substitution prior to bid and have been approved for use by the Engineer in Addenda issued prior to execution of the Contract.

G. Regulations:
   1. The term "Regulations" includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within the construction industry that control performance of the Work.

H. Furnish:

1. The term "furnish" is used to mean "supply and deliver to the Project site, ready for unloading, unpacking, assembly, installation, and similar operations.

I. Install:
1. The term "install" is used to describe operations at project site including the actual "unloading, unpacking, assembly, erection, fabrication, placing, anchoring, connecting, applying, working to dimension, finishing, curing, protecting, adjust and test except where otherwise specified, cleaning, and similar operations."

J. Provide:
1. The term "provide" means "to furnish and install, complete and ready for the intended use or operation."

K. Installer:
1. An "Installer" is the Contractor or an entity engaged by the Contractor, either as an employee, subcontractor, or contractor of lower tier for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.
2. The term "experienced," when used with the term "Installer," means having a minimum of five previous projects similar in size and scope to this Project, being familiar with the requirements indicated, and having complied with requirements of the authority having jurisdiction.

L. Trades:
1. Use of titles such as "carpentry" is not intended to imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as "carpenter." It also does not imply that requirements specified apply exclusively to trades persons of the corresponding generic name.

M. Assignment Specialist:
1. Certain Sections of the Specifications require that specific construction activities shall be performed by specialists who are recognized experts in the operations to be performed. The specialists must be engaged for those activities, and assignments are requirements over which the Contractor has no choice or option.
2. Nevertheless, the ultimate responsibility for fulfilling Contract requirements remains with the Contractor.
3. This requirement shall not be interpreted to conflict with enforcement of building codes and similar regulations governing the Work. It is also not intended to interfere with local trade union jurisdictional settlements and similar conventions.

N. Project Site:
1. Project site is the location of the project.

O. Contract Limits:

1. Contract Limits is the space available to the Contractor for performance of construction activities, either exclusively or in conjunction with others performing other work as part of the Project.
2. The extent of the Contract Limit is shown on the Drawings and may not be identical with the description of the Project Site.

P. Testing Agencies:
1. A "testing agency" is an independent entity engaged to perform specific inspections or tests, either at the Project Site or elsewhere, and to report on and, if required, to interpret results of those inspections or tests.

1.2 SPECIFICATION FORMAT AND CONTENT EXPLANATION

A. Specification Content:
1. This Specification uses certain conventions regarding the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions are explained as follows:
   a. Abbreviated Language: Language used in Specifications and other Contract Documents is abbreviated.
   b. Words and meanings shall be interpreted as appropriate.
   c. Words implied, but not stated, shall be interpolated as the sense requires.
   d. Singular words will be interpreted as plural and plural words interpreted as singular where applicable as the context of the Contract Documents indicates.
   e. Streamlined Language:
      1) The Specifications generally use the imperative mode and streamlined language. Requirements expressed in the imperative mode are to be performed by the Contractor.
      2) At certain locations in the Text, subjective language is used for clarity to describe responsibilities that must be fulfilled indirectly by the Contractor or by others when so noted.
2. The words “shall be” are implied where a colon (:) is used within a sentence or phrase.

1.3 INDUSTRY STANDARDS

A. Applicability of Standards:
1. Except where the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced.
2. Such standards are made a part of the Contract Documents by reference.

B. Publication Dates:
1. Comply with the standard in effect as of the date of the Contract Documents.

C. Conflicting Requirements:

1. Where compliance with two or more standards is specified, and the standards may establish different or conflicting requirements for minimum quantities or quality levels, the Contractor shall refer requirements that are different, but apparently equal, and uncertainties to the Engineer for a decision before proceeding.
    a. Minimum Quantity or Quality Levels:
        1) The quantity or quality level shown or specified shall be the minimum acceptable.
        2) The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum.
        3) To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of the requirements.
        4) Refer uncertainties to the Engineer for a decision before proceeding.

D. Copies of Standards:
1. Each entity engaged in construction on the Project is required to be familiar with industry standards applicable to that entity's construction activity.
2. Copies of applicable standards are not bound in the Contract Documents.
3. Where copies of standards are needed for performance of a required construction activity, the Contractor shall obtain copies directly from the publication source.
4. At a minimum furnish published standards (ASTM, AASHTO, ACI, ANSI, ASHRAE, SMACNA, UL, etc.) referred to or which are pertinent to these specifications.

E. Manufacturer’s installation Instructions:
1. Maintain at the job site a copy of all manufacturers’ installation instructions for all products provided or installed as part of this Contract.

1.4 ABBREVIATIONS:

A. General:
1. Trade association names and titles of general standards are frequently abbreviated.
2. Where such acronyms or abbreviations are used in the Specifications or other Contract Documents, they mean the recognized name of the trade association, standards generating organization, authority having jurisdiction, or other entity applicable to the context of the test provision.

1.5 ENGINEERURAL ABBREVIATIONS

A	compressed air lines
A/C	air conditioning
AB	anchor bolt
ABV	above
AC	acoustical
ACC	access, accessories
ACS DR	access door
ACS PNL	access panel
ACT	acoustical ceiling tile
AD	area drain
ADJ	adjustable
AFF	above finish floor
AFG	above finish grade

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AHR	anchor
AHU	air handling unit
ALT	alternate
ALUM, AL	aluminum
APPROX	approximate
ARCH	engineer(ural)
BB	bulletin board
BD	board
BFP	backflow preventer
BFV	butterfly valve
BITUM	bituminous
BLDG	building
BLK	block
BLKG	blocking
BM	bench mark
BOR	border
BOT	bottom
BR	bumper rail
BRG	bearing
BRK	brick
BTU	british thermal unit
BU	built up
BV	ball valve
C	channel
C&G	curb and gutter
C/HR	crash/hand rail
CAB	cabinet
CB	catch basin
CCT	cubicle curtain track
CD	condensate drain
CEM	cement
CF	chemical feed
CFLG	counterflash(ing),
CFM	cubic feet per minute
CG	corner guard
CHR	chair rail
CHWR	chilled water return
CHWS	chilled water supply
CI	cast iron
CJ	control joint
CL	center line
CLG	ceiling
CLO	closet
CLR	clear(ance)
CM	crown molding
CMU	concrete masonry unit
CNTR	counter
CO	cleanout
COL	column
CONC	concrete
CONSTR	construction
CONT	continuous or continue
CONTR	contract(or)
COORD	coordinate
CP	condensate pump discharge
CPT	carpet(ed)
CR	crash rail
CRS	course(s)
CSK	countersink/sunk
CT	ceramic tile
CU FT	cubic foot (or feet)
CU	copper
CVR	cover
CW	cold water piping
CWR	condenser supply return
CWS	condenser supply water
CY	
D	drain
DBL	double
DET	detail
DIA	diameter
DIM	dimension
DISP	dispenser
DIST	distribution
DM PF	damproofing
DN	down
DR OPNG	door opening
DR	door
DS	downspout
DSPL	disposal (disposed)
DTA	drip trap assembly

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DW	dumbwaiter
DWG	drawing(s)
DWR	drawer
DX	direct expansion
E	east
EA	each
EC	electrical contractor
EG	edge guard
EIFS	exterior insulating finish system
EHO	electric hold open
EJ	expansion joint
EL	elevation
ELEC	electric(al)
EMER	emergency
EP	epoxy paint
EQ	equal
EQUIP	equipment
EWC	electric water cooler
EWS	eye wash station
EX/EXIST	existing
EXH FN	exhaust fan
EXH	exhaust
EXP BT	expansion bolt/s
EXP	exposed, expansion
EXT	exterior
EXTR	extruded
F&T	float & thermostat
FACP	fire alarm cabinet panel
FCO	flow cleanout
FD	floor drain
FDTH	foundation
FE	fire extinguisher
FEC	fire extinguisher cabinet
FF EL	finish floor elevation
FHC	fire hose cabinet
FHVC	fire hose valve cabinet
FIN FL	finished floor
FIN	finish(ed)
FIX	fixture
FLASH	flashing
FLEX	flexible
FLR SK	floor sink
FLR	floor(ing)
FLSW	flow switch
FLUOR	fluorescent
FMT	floor mounted toilet
FOC	face of concrete
FOF	face of finish
FOM	face of masonry
FOS	face of studs
FOW	face of wall
FP	fireproof(ing)
FR	fire rated
FRP	fiberglass reinforced plastic
FT	foot
FTG	footing
FVB	film view box
FWC	fabric wall covering
G	natural gas line
GA	gage, gauge
GALV	galvanized
GB	grab bar
GC	general contract(or)
GFRC/GRC	glass fiber reinforced cement
GRG	glass fiber reinforced gypsum
GL	glass, glazing
GLZ CMU	glazed masonry unit
GND	ground
GSKT	gasket(ed)
GSU	glazed structural unit
GTV	gate valve
GW	grease waste
GYP BD	gypsum board
HB	hose bibb
HC	handicap
HD	heavy duty, hub drain
HDW	hardware
HDWB	hardboard
HDWS	hardwood

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HGT	height
HK	hook(s)
HM	hollow metal
HO	hold opening
HORIZ	horizontal
HP	horsepower, high-pressure, heatpump
HPR	high pressure steam return 125psi
HPS	high pressure steam supply 125psi
HR	handrail/hourly rating
HSR	hose reel
HVAC	heating/ventilating/air conditioning
HW	hot water
HWF	hardwood flooring
HWR	hot water return
HWS	hot water supply
ID	inside diameter
IN	inch
INCL	include(d), (ing)
INSUL	insulation
INT	interior
INV	invert
IP	iron pipe
IVT	i.v. track
JST	joist
JT	joint
KEYBD	keyboard
L	angle
LAD	ladder
LAM GL	laminated glass
LAM	laminate(d)
LAV	lavatory
LB (#)	pound
LBL	label
LF	linear foot
LKR	locker
LL	live load/lead lined
LPG	liquid petroleum gas
LPR	low pressure steam return 15psi
LPS	low pressure steam supply 15psi
LT WT	lightweight
LTG	lighting
LTL	lintel
LVL	laminated veneer lumber
LVR	louver
MAS	masonry
MATL	material
MAX	maximum
MB	marker board
MBR	member
MC	
MC	medicine cabinet
MCB	marker/chalk board
MCFD	mineral core fire door
MECH	mechanical
MEZZ	mezzanine
MFR	manufacture(r)
MH	manhole
MHO	manual hold open
MIN	minimum
MISC	miscellaneous
MO	masonry opening
MPR	medium pressure steam return (60psi)
MPS	medium pressure steam supply (60psi)
MRBL	marble
MTB	marker/tack board
MTD	mounted
MTG HT	mounting height
MTG	mounting
MTL	metal
MULL	mullion
N/A	not applicable
n2	nitrogen line
n2o	nitrous oxide line
NC	non-combustible
NIC	not in contract
NO (#)	number
NOM	nominal

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NTS	not to scale
O	
OA	
OC	on center(s)
OCBW	on center both ways
OCH	on center horizontally
OCV	on center vertically
OD	outside diameter, overflow drain
OH	overhead
OHS	open hearth steel
OPNG	opening
OPP	opposite
ORD	overflow roof drain
PC	particle core
PC	plumbing contractor
PCF	pounds per cubic foot
PE	paint eggshell
PED	pedimat
PF	paint flat
PL	plate
PLAM	plastic laminate
PLAS	plaster
PLBG	plumbing
PLYWD	plywood
PNL	panel
PNT	paint(ed)
POR	porcelain
PR CST	precast
PR KG	parking
PR	pair
PRV	pressure reducing valve
PS	paint semi-gloss
PSF	pounds per square foot
PSI	pounds per square inch
PT	pressure treated
PTD	paper towel dispenser
PTHR	pass-thru
PTN	partition
PTS	pneumatic tube station
PV	plug valve
PVC	polyvinyl chloride
PVCB	PVC base
PVMT	pavement
PVR	paver
PW	pass window
PWR	power
QT	quarry tile
RAD	radius
RB	rubber base
RBR	rubber or radius
RCP	reinforced concrete pipe
RD	roof drain
RECP	receptor (ACLE)
REF	reference, refrigerator
REINF	reinforce(d), (ing), (ment)
REQD	required
RES	resilient
RET	retaining
REV	revision(s), revised
RF	roof
RFG	roofing
RH	roof hatch
RL	roof leader
RM	room
RO	rough opening
RST	rubber stair tread
RT	rubber tile
RTF	resilient textile flooring
RTU	roof top unit
RWL	rain water leader
S	south, switch
S&R	shelf and rod
SAD	security access door
SAP	secure access panel
SB	splash block
SC	solid core (doors)
SCR	shower curtain rod
SD	storm drain
SEC	security
SECT	section
SFPS	stretched fabric panel system

oxygen
overall

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SHM	security hollow metal
SHR	shower
SHT	sheet
SHT'G	sheathing
SHV	shelf, shelving
SIM	similar
SL	slope
SLC	solid stave core
SOG	slab on grade
SP	soundproof
SPEC	specification(s) (specified)
SQ	square
SR	seamless resilient
SS	sanitary sewer
SSM	solid surface material
SST	stainless steel
ST	stone
STC	sound transmission coefficient
STD	standard
STER	sterilizer
STL	steel
STN	stained
STRUCT	structural
SUS	suspended
SV	sheet vinyl/ safety relief valve
SWGR	switchgear
T&G	tongue & grove
TB	towel bar
TEL	telephone
TEMP	temporary
TER	terrazzo
TF	texture floor
THK	thick(ness)
THRES	threshold
THRU	through
TKBD	tackboard
TLT	toilet
TOC	top of curb
TOM	top of masonry
TOS	top of steel
TOW	top of wall
TPD	toilet paper dispenser
TPTN	toilet partition
TRS	tool resistive steel
TRTD	treated
TS	tube steel
TV	television
TYP	typical
UC	undercut/undercounter
UL	underwriter's laboratories
UNO	unless noted otherwise
UR	urinal
V	
VAC	vacuum
VC	variegated coating
VCT	vinyl composition tile
VERT	vertical
VIF	verify in field
VIN	vinyl
VR	vapor retarder
VT	vinyl tile
VTR	vent trough roof
VWC	vinyl wall covering
VWF	vinyl wall fabric
W	wide
W/	with
W/O	without
WALG	wall guard
WC	watercloset
WCJ	wall control joint
WCO	
WD	wood
WDM	waterproofing membrane
WG	wired glass
WH	water hydrant
WI	wrought iron
WIN	window
WO	window opening
WOM	walk off mat
WP	waterproofing
WR	water resistant
WS	wall sconce

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WSCT	wainscot	WSSV	welded sheet vinyl
WWF	welded wire fabric		

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 014210

SECTION 015000 - TEMPORARY FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Work Specified In This Section:
   1. This Section specifies requirements for temporary services and facilities, including utilities, construction and support facilities, security and protection.

1.2 QUALITY ASSURANCE

A. Regulations:
   1. Comply with industry standards and applicable laws and regulations of authorities having jurisdiction.

B. Electrical Service:
   1. Comply with NEMA, NECA and UL standards and regulations for temporary electric service. Install service in compliance with National Electric Code (NFPA 70).

1.3 PROJECT CONDITIONS

A. Conditions of Use:
   1. Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Take necessary fire prevention measures. Do not allow hazardous dangerous or unsanitary conditions, or public nuisances to develop or persist on the site.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Lumber and Plywood:
   1. Comply with requirements in Division-6.

2.2 TEMPORARY FACILITIES

A. Drainage:

1. Keep excavations, pits, trenches, footings, and floors free from water to protect all work and to afford satisfactory working conditions. Provide any temporary ditches, sumps, pumps, or drains necessary for this purpose.

B. Water Service:
1. Provide, protect, and maintain a system of temporary water service, including all associated cost.
2. Provide additional service if required for temporary air conditioning.

C. Stairs, Ramps, Chutes and Hoists:
1. The General Contractor shall provide and maintain temporary stairs, ramps, trash chutes and runways as required.
2. The General Contractor shall provide a materials hoist which shall be suitable for the use of all trades.
3. All apparatus, equipment, and construction shall be in accordance with all applicable State and local laws.
4. Hoisting of materials and equipment shall be provided by the Contractor requiring same.

D. Barricades, Warning Signs and Lights:
1. Comply with standards and code requirements for erection of structurally adequate barricades. Paint with appropriate colors, graphics and warning signs to inform personnel and the public of the hazard being protected against. Where appropriate and needed provide lighting, including flashing red or amber lights.

E. Temporary Parking:
1. Use of Owner's parking lots will be permitted. The Contractor’s company vehicles may be parked in designated parking areas determined during the Pre-Construction Meeting.

F. Temporary Storage:
1. Only the area as directed by the Owner may be used for storing materials.

G. Removal of Temporary Work:
1. Remove from the premises, on or before completion of work, all temporary facilities.

2.3 TEMPORARY OVERHEAD PROTECTION:

A. Provide all necessary measures to protect vehicles parked in the vicinity of the Contractor’s operations from damage, particularly from over-spray during pressure washing and from painting operations.

2.4 PROJECT SITE SIGN

A. No project signs are allowed on this project except those approved by the owner.

PART 3 - EXECUTION

3.1 TEMPORARY CONSTRUCTION AND SUPPORT FACILITIES INSTALLATION

A. Maintain temporary construction and support facilities until Substantial Completion unless otherwise approved by owner. Remove prior to Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to the Owner.

END OF SECTION 015000

SECTION 016310 - PRODUCT SUBSTITUTIONS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Specified This Section:
   1. This Section specifies administrative and procedural requirements for handling requests as a substitution request made after the Notice to Proceed or award of the Contract as a CPR.

1.2 SUBMITTALS

A. Substitution Request Submittal:
   1. Submit 3 copies of each request for substitution for consideration.
   2. Submit each request on the attached form and in accordance with procedures required for Change Proposal Requests (CPR). See Section 01250 for additional information.
   3. Identify the product, or the fabrication or installation method to be replaced in each request. Include related Specification Section and Drawing numbers.
   4. Provide complete documentation showing compliance with the requirements for substitutions, and the following information, as appropriate:
      a. Original copies of Product Data, including Drawings and descriptions of products, fabrication and installation procedures.
      b. Samples, where applicable or requested.
      c. A detailed point by point comparison of the proposed substitution and the specified product detailing the significant qualities of both products.
         1) Significant qualities may include elements such as size, weight, durability, performance and visual effect.
      d. Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by the Owner and separate Contractors that will become necessary to accommodate the proposed substitution.
      e. A statement indicating the substitutions effect on the Contractor's Construction Schedule.
      f. Cost information, including a proposal of the net deduct change in the Contract Sum.
      g. Certification by the Contractor that the substitution proposed is equal-to or better in every significant respect to that required by the Contract Documents, and that it will perform adequately in the application indicated.
         1) Include the Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of the failure of the substitution to perform adequately.

B. Engineer's Action:
   1. After receipt of the request for substitution, the Engineer may request additional information or documentation necessary for evaluation of the request.
   2. If a decision on use of a proposed substitute is not made or obtained within sufficient time to have no adverse impact on the construction schedule, the Contractor shall use the product specified in the Contract Documents.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 SUBSTITUTIONS:

A. Conditions:
   1. No substitution will be considered unless such request include the name of the material or equipment for which it is to be substituted and a complete description of the proposed substitution including drawings, performance and test data, and other information necessary for a complete comparison with the specified products or materials and an evaluation of the proposed products or materials.
   2. A statement setting forth changes in other materials, equipment or other portions of the Work including changes in the work of other contracts that incorporation of the proposed substitution would require shall be included.
   3. Savings or Credit to Owner for accepting substitution
   4. The burden of proof of the merit of the proposed substitution is upon the proposer.
   5. In addition to the requirements in the Supplemental General Conditions, the following items will apply:
      a. The substitution is in compliance with subsequent interpretations of code or insurance requirements.
      b. The manufacturer or fabricator shall certify or guarantee the specified product as required by the Contract Documents.
      c. Product shall perform properly and fit in the designated space.

B. The Contractor shall bear all expenses resulting from substitutions including the cost of work in general, structural, plumbing, mechanical and electrical trades required due to the substitution and the cost of any Engineer's services made necessary by the substitution.

C. The Engineer's decision of approval or disapproval of a proposed substitution shall be final.

3.2 SUBMITTAL FORMS:

A. All proposed substitutions shall use the following form.

PART 4 - SUBSTITUTION

REQUEST

Project: _____ Substitution Request No_____

_____ CPR No. (After Bid) _____

_____ From: _____

To: _____ Date: _____

_____ A/E Project No. _____

Re: _____ Contract For: _____

Specification Title/or Drawing Sheet:_____

Section No.: _____ Page No.: _____ Article/Paragraph:_____

Proposed Substitution: _____

Manufacturer:_____ Address:_____ Phone #:_____

Trade Name:_____ Model #:_____

Installer:_____ Address:_____ Phone #:_____

History: New Product: 2 -5 years old 5-10 years old More than ten years old

Briefly explain differences between proposed substitution and specified product _____

_____

_____

Point-by-Point comparative data attached - REQUIRED BY A/E

Reason for not providing specified item: _____

_____

_____

Similar Installation:

Project:_____ Engineer:_____

Address:_____ Owner:_____

Owner Representative:_____

Telephone:_____

Date Installed: _____

Proposed substitution affects other parts of Work: No Yes; explain _____

_____

_____

Savings or Credit to Owner for accepting substitution:_____($_____)

(MUST BE FILLED OUT TO RECEIVE REVIEW.)

Proposed substitution changes Contract Time: No Yes; Add/Deduct_____ days.

Supporting Data Attached:

Product Data	Drawings	Tests	Reports	Samples _____
Fire Tests	Acoustical Tests			
ASTM Tests	UL, FM or WHI listed: provide copy of test reports.			

Undersigned certifies:

- Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
- Same or better warranty will be furnished for proposed substitution as for specified product.
- Same or better maintenance service and source of replacement parts, as applicable is available.
- Proposed substitution will not affect or delay Progress Schedule.
- Cost data as stated above is complete. Contractor (s) claims for additional costs related to accepted substitution, which may subsequently become apparent are to be waived.

- Proposed substitution does not affect dimensions and functional clearances.
- Payment will be made for A/E changes to building design, including engineerural or engineering design, detailing, and construction costs caused by the requested substitution.
- Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitted By: _____

Signature: _____

Firm: _____

Address: _____

_____

Telephone:_____ Approved By: _____ _____
General Contractor Date

Attachments: _____

_____

_____

ENGINEER'S REVIEW AND ACTION

Substitution approved - Make submittals in accordance with Division One.

Substitution approved as noted - Make submittals in accordance with Division One.

Substitution rejected - Use specified materials.

Signed by: _____ Date: _____

Additional Comments Contractor Subcontractor Supplier Manufacturer A/E

END OF SECTION 016310

SECTION 017810 - PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included This Section:
   1. This Section specifies administrative and procedural requirements for project closeout, including but not limited to:
      a. Inspection procedures.
      b. Project record document submittal.
      c. Operating and maintenance manual submittal.
      d. Submittal of warranties.
      e. Access badges and parking passes
   2. Closeout requirements for specific construction activities are included in the appropriate Sections in Divisions 2 through 16.

1.2 SUBSTANTIAL COMPLETION

A. General:
   1. The Work or designated portion thereof will not be considered suitable for Substantial Completion until all systems are operational as designed; all designated or required governmental inspections or certifications have been made and posted, including those of the Division of Health Service Regulation (DHSR), designated instruction of Owner's personnel in the operation of systems has been completed, and all final finishes are in place.
   2. As a further condition of Substantial Completion, the Contractor(s) shall certify that all remaining work will be completed within 30 consecutive calendar days following the Date of Substantial Completion, and the failure to do so shall automatically reinstate the provisions for damages due the Owner as contained elsewhere in the Agreement or as provided by law for such period of time as may be required by the Contractor to fully complete the work whether the Owner has occupied the work or not.
   3. Upon Substantial Completion of the Work or designated portion thereof and upon application by the Contractor and recommendation by the Architect, the Owner shall make payment, reflecting adjustment in retainage, if any, for such Work or portion thereof as provided in the Contract Documents.

B. Forms:
   1. All forms to be used shall be American Institute of Architect (AIA) forms.

C. Preliminary Procedures:
   1. Advise Owner of pending insurance changeover requirements.

2. Submit specific warranties, workmanship bonds, maintenance agreements, final certifications and similar documents.
3. Obtain and submit releases enabling the Owner unrestricted use of the Work and access to services and utilities; include occupancy permits, operating certificates and similar releases.
4. Deliver tools, spare parts, extra stock, and similar items.
5. Make final changeover of permanent locks and transmit keys to the Owner.
    a. Advise the Owner's personnel of changeover in security provisions.
6. Complete start-up testing of systems, and instruction of the Owner's operating and maintenance personnel.
    a. Discontinue or change over and remove temporary facilities from the site, along with construction tools, mock-ups, and similar elements.
7. Complete final clean up requirements, including touch-up painting.
    a. Touch-up and otherwise repair and restore marred exposed finishes.

D. Inspection Procedures:
1. Upon receipt of a request for inspection for Substantial Completion, the Architect will either proceed with inspection or advise the Contractor(s) of incomplete requirements.
    a. The Architect will prepare the Certificate of Substantial Completion following inspection, or advise the Contractor of construction that must be completed or corrected before the certificate will be issued.
2. The Architect will repeat inspection when requested in writing by the Contractor and assured that the Work has been substantially completed and all items that were incomplete have been corrected.
3. Results of the completed inspection will form the basis of requirements for final acceptance.

E. Re-inspection Procedure:
1. In the event that more than the two inspections by the Architect, described above are made necessary by the failure of the Contractor(s) to complete the work or to complete or correct items identified on the list of such items, a CPR will be established for re-inspection.
    a. The Contractor(s) shall reimburse the Owner for all costs incurred including the cost of the Architect's services made necessary thereby.
2. Upon completion of re-inspection, the Architect will prepare a Certificate of Substantial Completion, or advise the Contractor of Work that is incomplete or of obligations that have not been fulfilled but are required for Substantial Completion.
3. If necessary, a CPR will be established for re-inspection will be repeated at the Contractor's expense and the amount deducted from his Application for Payment.

1.3 FINAL ACCEPTANCE

A. At the completion of the Project prior to receiving final payment, the Contractor shall furnish the Owner, through the Architect, properly signed and notarized waivers of lien from all subcontractors employed and material suppliers furnishing materials for the Project. Such

waivers shall be submitted before final payment will be certified by the Architect to the Owner (AIA G706A).

B. Preliminary Procedures:
   1. Before requesting final inspection for final payment, submit and complete the following (list exceptions in the request):
      a. Submit a copy of the Architect's final inspection list of items to be completed or corrected, stating that each item has been completed or otherwise resolved for acceptance and the list has been endorsed and dated by the Architect.
      b. Submit record drawings, maintenance manuals, final project photographs (if any), and similar final record information.
      c. Submit Consent of Surety to Final Payment (AIA G707).
      d. Guarantees, Warranties and Bonds.
      e. Keys and keying schedule.
      f. Spare parts and Maintenance Materials.
      g. Certificate of Insurance for Products and Completed Operations.
      h. Certificate of Occupancy if required.
      i. All remnants required by the Contract Documents.
      j. Return access badges and parking passes to F+P Project Manager
      k. Any other items as required by the Architect and/or Owner.

1.4 RECORD DOCUMENT SUBMITTALS

A. General:
   1. The Contractor(s) shall record on the Record Drawings maintained at the site all changes and selections made during construction and shall locate by dimensions showing actual field measurements of all major items which will be concealed in the completed Work.
      a. These items shall include underground piping and conduit beneath slabs-on-grade (or basement slabs), underground site utilities such as pipe, conduit, storm drainage, sewer, gas, water, medical gases, oil, and telephone etc. and items above hard ceilings such as duct, pipe, etc.
      b. Elevations are to be established at fifty foot intervals and at all changes in direction using bench marks or finish floor elevations.
   2. Dimensions are to be taken from face of building lines to centerline of piping or conduit.
   3. The Contractor will accurately locate all under floor services at slab on grade areas by dimension from building line or column centerlines.
      a. Elevations are to be established from finish floor lines.
   4. Where new lines cross existing installed lines the location, size and type of line crossed shall be accurately recorded.
   5. Where tie-ins to existing under floor lines are indicated the elevation of the tie-in point and dimensioned location shall be recorded.
   6. Do not use record documents for construction purposes; protect from deterioration and loss in a secure, fire-resistive location; provide access to record documents for the Architect's reference during normal working hours.

B. Record Drawings:
   1. Record drawings shall be provided to reflect changes (CPRs) in the Work and locations of concealed items for all trades including plumbing, mechanical, electrical, and general construction.
   2. Mark the set, using red, to show the actual installation where the installation varies substantially from the Work as originally shown.
   3. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings.
      a. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
   4. Mark new information that is important to the Owner, but was not shown on Contract Drawings or Shop Drawings.
   5. Note related Change Order numbers where applicable.

C. Record Specifications:
   1. Maintain one complete copy of the Project Manual, including addenda, and one copy of other written construction documents such as Change Orders (CPRs) and modifications issued in printed form during construction.
      a. Mark these documents to show variations in actual Work performed in comparison with the text of the Specifications and modifications.
      b. Give particular attention to substitutions, selection of options and similar information on elements that are concealed or cannot otherwise be readily discerned later by direct observation.
      c. Note related record drawing information and Product Data.
   2. Upon completion of the Work, submit record Specifications to the Architect for the Owner's records.

D. Shop Drawings:
   1. Deliver Contractor's approved copy of all shop drawings submitted during the course of the project.

E. Miscellaneous Record Submittals:
   1. Refer to other Specification Sections for requirements of miscellaneous record-keeping and submittals in connection with actual performance of the Work.
   2. Immediately prior to the date or dates of Substantial Completion, complete miscellaneous records and place in good order, properly identified and bound or filed, ready for continued use and reference.
   3. Submit to the Architect for the Owner's records.
   4.

1.5 OPERATING AND MAINTENANCE MANUAL INSTRUCTIONS

A. Prior to Substantial Completion, the Contractor shall deliver to the Architect one electronic copy of the operating and maintenance (O&M) manual; assembled and indexed; presenting

for the Owner's guidance full details for care and maintenance of the general construction building items (automatic doors, elevators, flooring, roofs, etc.); and the fire protection, plumbing, HVAC, electrical, and other miscellaneous equipment included in Contract.

1. O&M manual shall be prepared using Adobe Acrobat software (Version 10 or later) to create electronic PDF files of the manual contents. Prepare the electronic O&M manual according to the following instructions.
    a. Obtain original PDF files of O&M literature from subcontractors and vendors. Scanned copies of paper files are not acceptable.
        1) The O&M literature of the equipment shall include, but not be limited to, technical data of the equipment, wiring diagrams, routine maintenance instructions, and other information necessary for the proper operation of the equipment.
        2) Include the approved submittal for each item of equipment.
        3) Include a complete parts list for each item of equipment.
        4) Include MSDS sheets, if applicable, for each item of equipment.
        5) Include the name, address, and phone number of the nearest sales and service organization for each item.
    b. Organize contents by CSI division.
    c. Name individual equipment O&M files by CSI division so that the individual files can be combined into a single PDF file. In doing so, Adobe Acrobat will automatically create “bookmarking” which will allow the Owner to search and navigate the O&M manual quickly and easily to find individual contents of the combined PDF file.
        1) Example: Two different types of pumps are specified in section “15185 HVAC Pumps” – the first is an end-suction centrifugal pump, and the second is a double-suction centrifugal pump. Each pump has different O&M instructions. As such, the individual file for the end-suction pump would be named “15185.01 End-Suction Pumps”, and the file for the double-suction pump would be named “15185.02 Double-Suction Pumps.”
    d. After the individual PDF files are created, the Contractor shall select all the individual files and combine them into a single file using the “Combine supported files in Acrobat” feature.
    e. The combined PDF file of the O&M manual shall be stored on a properly labeled compact disc for the project.

B. Drawings:

1. Where drawings or diagrams are required as part of the manual, provide original, legible PDF files of the drawings. .
2. Organize and name drawings so that they are assembled and indexed with the equipment O&M files they are associated with.

C. Cover Page:
1. Provide a cover page at the beginning of the O&M manual. Provide the following information:
    a. Name of the Owner.

b. Name and address of the facility.
c. Name of project.
d. Date of O&M manual submittal.
e. Name, address, and telephone number of the General Contractor.
f. Name, address, and telephone number of the Architect/Engineer;

D. Table of Contents:
1. After the Cover Page, include a table of contents for the O&M manual, organized by CSI division and arranged systematically according to the Project Manual format. Include a list of each product identified by the product's CSI division and name indexed to the content of the O&M manual.

E. Project Team Report:
1. Include a Project Team Report section immediately following the Table of Contents listing the name, address, and phone number of the General Contractor; and each subcontractor and/or vendor and the division of work for which they were responsible.

F. Authorities Having Jurisdiction Approvals:
1. Include an Authorities Having Jurisdiction (AHJ) Approvals section immediately following the Project Team Report that includes the Certificate(s) of Occupancy, Fire Marshal Inspection, and any other AHJ approval documents obtained for the project.

G. Project Warranties:
1. Include a Project Warranties section immediately following the Authorities Having Jurisdiction Approvals that includes warranty letters from the General Contractor; and each subcontractor for the division of work for which they were responsible.

H. Product Data (Divisions 2 through 16):
1. Include Product Data sections for each item of equipment immediately following the Project Warranties organized and tabulated by the product's CSI division. Provide a separate tabulated section for each CSI division of products.
2. Where manufacturer's standard printed data is included in the O&M manual, include only sheets that are pertinent to the part or product installed.
3. Mark each sheet to identify each part or product included in the installation.
4. Where more than one item in a tabular format is included, identify each item, using appropriate references from the Contract Documents.
5. Identify data that is applicable to the installation and delete references to information that is not applicable.

I. Written Text:
1. Where manufacturer's standard printed data is not available, and information is necessary for proper operation and maintenance of equipment or systems, or it is necessary to provide additional information to supplement data included in the manual, prepare written text to provide necessary information.
2. Organize the text in a consistent format under separate headings for different procedures.

3. Where necessary, provide a logical sequence of instruction for each operating or maintenance procedure.

J. Warranties, Bonds and Service Contracts:
1. Provide a copy of each warranty, bond or service contract in the General Information section of the O&M manual.
2. Provide written data outlining procedures to be followed in the event of product failure.
3. List circumstances and conditions that would affect validity of the warranty or bond.

1.6 INSTRUCTIONS

A. The Owner's delegated representative shall be given personal instructions by trained personnel, in the care, use, maintenance, and operation procedures for each item.
1. This shall be done in accordance with, and in addition to, the above required manual.

B. Operating and Maintenance Instructions:
1. Arrange for each installer of equipment that requires regular maintenance to meet with the Owner's personnel to provide instruction in proper operation and maintenance.
2. If installers are not experienced in procedures, provide instruction by manufacturer's representatives.
3. Include a detailed review of the following items:
a. Maintenance manuals.
b. Record documents.
c. Spare parts and materials.
d. Tools.
e. Identification systems.
f. Control sequences.
4. As part of instruction for operating equipment, demonstrate the following procedures:
a. Start-up.
b. Shutdown.
c. Emergency operations.
d. Noise and vibration adjustments.
e. Safety procedures.
f. Economy and efficiency adjustments.
g. Effective energy utilization.

C. Maintenance Procedures:
1. Provide information detailing essential maintenance procedures, including the following:
a. Routine operations.
b. Trouble-shooting guide.
c. Disassembly, repair and re-assembly.
d. Alignment, adjusting and checking.

D. Operating Procedures:

1. Provide information on equipment and system operating procedures, including the following:
    a. Start-up procedures.
    b. Equipment or system break-in.
    c. Routine and normal operating instructions.
    d. Regulation and control procedures.
    e. Instructions on stopping.
    f. Shutdown and emergency instructions.
    g. Summer and winter operating instructions.
    h. Required sequences for electric or electronic systems.
    i. Special operating Instructions.

E. Servicing Schedule:
1. Provide a schedule of routine servicing and lubrication requirements, including a list of required lubricants for equipment with moving parts.

F. Controls:
1. Provide a description of the sequence of operation and as-installed control diagrams by the control manufacturer for systems requiring controls.

G. Coordination Drawings:
1. Provide each Contractor's Coordination Drawings.
2. Provide as-installed color-coded piping diagrams, where required for identification.

H. Valve Tags:
1. Provide charts of valve tag numbers, with the location and function of each valve.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 017810

SECTION 017880 - WARRANTIES AND BONDS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Included This Section:
   1. This Section specifies general administrative and procedural requirements for warranties and bonds required by the Contract Documents, including manufacturer's standard warranties on products and special warranties.
   2. Specific requirements for warranties for the Work and products and installations that are specified to be warranted are included in the individual Sections of Divisions 2 through 16.
   3. Certifications and other commitments and agreements for continuing services to Owner are specified in the Contract Documents.

B. Disclaimers and Limitations:
   1. Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the Work that incorporates the products, nor does it relieve suppliers, manufacturers, and subcontractors required to countersign warranties with the Contractor.
   2. At no time shall any warranties/guarantees be submitted to the Owner for this project which supercedes or voids any of the Owners rights as established by the state's General Statutes for which the project is located.
   3. Failure of the Contractor and/or its suppliers, manufacturers and its sub-contractors to enter into such warranties as required by the Contract Documents shall be considered a breach of contract.

1.2 WARRANTY REQUIREMENTS

A. Related Damages and Losses:
   1. When correcting warranted Work that has failed, remove and replace other Work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted Work. Do not reuse damaged materials.

B. General labor and material warranty period shall be 12 months in duration as established by the Certificate of Substantial Completion.

C. Warranty Walk through with Owner:
   1. Commencing with the tenth month after substantial completion and during the instated warranty period, The Owner reserves the right to request the Contractor, subcontractor, supplier, or manufacturer to attend a project walk through and review any deficiencies

or items that may require repair or replacement prior to the warranty period expiration.

1.3 SUBMITTALS

A. Written Warranties:
1. Submit written warranties to the Architect prior to Substantial Completion in a separate three ring binder. The Architect's Certificate of Substantial Completion designates a commencement date for warranties.
2. Prepare a written document utilizing the appropriate form, ready for execution by the Contractor, or the Contractor and subcontractor, supplier or manufacturer.
3. Refer to individual Sections for specific content requirements, and particular requirements for submittal of special warranties.

B. Form of Submittal:
1. At Final Completion compile two copies of each required warranty and bond properly executed by the Contractor, or by the Contractor, subcontractor, supplier, or manufacturer. Organize the warranty documents into an orderly sequence based on the Table of Contents of the Project Manual. Deliver all warranties to the Architect before or with the Request for Substantial Completion.

C. Reinstatement of Warranty:
1. When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement.
2. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

D. Replacement Cost:
1. Upon determination that work covered by a warranty has failed, replace or rebuild the work to an acceptable condition complying with requirements of Contract Documents.
2. The Contractor is responsible for the cost of replacing or rebuilding defective work regardless of whether the Owner has benefited from use of Work through a portion of its anticipated useful service life.

E. Owner's Recourse:
1. Written warranties made to the Owner are in addition to implied warranties, and shall not limit the duties, obligations, rights and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitations on time in which the Owner can enforce such other duties, obligations, rights, or remedies.

F. Rejection of Warranties:
1. The Owner reserves the right to reject warranties and to limit selections to products with warranties not in conflict with requirements of the Contract Documents.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 017880

SECTION 230010 - HVAC SUMMARY

PART 1 - GENERAL

1.1 SUMMARY

A. The heating, ventilating and air-conditioning systems design includes the M drawing sheets and the following Division 23 and 25 specification sections.

NUMBER	TITLE
23 05 13	Common Motor Requirements HVAC Equipment
23 05 29	Hangers and Supports HVAC Piping and Equipment
23 05 33	Heat Tracing HVAC Piping
23 05 53	Fiberglass Reinforced Plastic Centrifugal Utility Fans
23 05 53	Identification HVAC Piping and Equipment
23 05 93	Testing Adjusting and Balancing HVAC
23 07 19	HVAC Piping Insulation
23 09 23	Direct Digital Control System for HVAC
23 21 13	Hydronic Piping
23 21 23	Hydronic Pumps
23 23 00	Refrigerant Piping
23 25 00	HVAC Water Treatment
23 31 13	Metal Ducts
23 31 16	Nonmetal Ducts
23 33 00	Air Duct Accessories
23 34 16	Inline Centrifugal Fans
23 34 23	HVAC Power Ventilators
23 64 26	Variable Speed Air-Cooled Screw Compressor Chiller
23 81 26	Split-System Air-Conditioners

PART 2 - RODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 230010

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency accepted by the Authority Having Jurisdiction and marked for intended location and application.
   1. Listing agencies of electrical and mechanical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

B. Motor controllers.

C. Torque, speed, and horsepower requirements of the load.

D. Ratings and characteristics of supply circuit and required control sequence.

E. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

D. All motors shall be premium efficiency

E. Each motor one (1) horsepower or larger shall have a composite power factor (PF) rating of 90% to 100% when the driven equipment is operating at design duty.

F. Totally enclosed fan cooled (TEFC) motors shall be utilized for exterior applications, including 100% outside air air-handling equipment and laboratory exhaust fans.

G. Bearings shall be ball or roller cylindrical bearings with an L-10 life of 40,000 hours with an external load and L-10 life of 100,000 hours in direct coupled applications. Motor shall be dynamically balanced to 0.1 inch/per/second.

H. Motors for fans and pumps shall be selected for the maximum brake-horsepower listed in the equipment schedules and no more than 85% of the nominal rated horsepower excluding the service factor.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C 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.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.
   1. General Use: Open drip-proof (ODP) motors.
   2. Laboratory Roof Exhaust: Totally enclosed fan cooled (TEFC).

B. Efficiency: Energy 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.

2.4 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. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   4. Over-Speeding: Variable frequency drives shall not be set above 60 Hz.

C. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.

D. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

E. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

F. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

G. Explosion Proof Motors: Class 1 listed and labeled for the design environment.

2.5 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 (Not Applicable)

END OF SECTION 230513

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 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.

1.2 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."

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC pipig and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.4 ACTION 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.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for seismic restraints. 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. Fiberglass strut systems. Include Product Data for components.
   4. Pipe stands. Include Product Data for components.
   5. Equipment supports.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates

1.6 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 METAL 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. Carbon-Steel Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Hangers shall be galvanized. Padded hangers shall have fiberglass pad or cushion to support bearing surface of piping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.

C. Stainless-Steel Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Hangers shall be stainless steel. Padded hangers shall have fiberglass pad or cushion to support bearing surface of piping. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

D. Copper Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Hangers shall be copper-coated-steel. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

E. 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.

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

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

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

2.3 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.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components for supporting multiple parallel pipes. Channels shall be continuous slotted steel with in-turned lips. Channel nuts shall be designed to fit into channel slot and when tightened to prevent slipping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.

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.

2.5 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. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or 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.

2.6 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.

2.7 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.

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

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   1. Base: Stainless steel.
   2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. 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.

2.8 EQUIPMENT SUPPORTS

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

2.9 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

3.1 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 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 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 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.

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.

3.2 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. Refer to Division 07 Section "Roof Accessories" for curbs.

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 2-1/2 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.

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 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.

3.3 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.

3.4 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.

3.5 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.

3.6 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 are specified in Division 09 painting Sections.

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

END OF SECTION 230529

SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes heat tracing with the following electric heating cables:
   1. Plastic insulated, series resistance.
   2. Self-regulating, parallel resistance.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
   1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.3 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.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
   1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Easy Heat Inc.
   2. Raychem; a division of Tyco Thermal Controls.
   3. Thermon Manufacturing Co.

B. Heating Element: Pair of parallel No. 16 AWG, nickel-coated stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Tinned-copper braid and polyolefin outer jacket with UV inhibitor.

E. Maximum Operating Temperature (Power On): 150 deg F

2.2 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

B. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

C. Corrosion-resistant, waterproof control enclosure.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Division 23 Section "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.

2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
   2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Division 23 Section "HVAC Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

G. Protect installed heating cables, including nonheating leads, from damage.

3.3 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."

3.4 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

1. Test cables for electrical continuity and insulation integrity before energizing.
2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 230533

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 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.

1.3 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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.
3. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.
6. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

D. 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.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 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 1 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.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. 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 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Blue.

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 1 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. 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 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond 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.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 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

3.1 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.

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 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 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Pipe Label Color Schedule:
   1. Chilled-Water Piping:
      a. Background Color: Green.
      b. Letter Color: White.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated, self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
   4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 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.
   2. Valve-Tag Color:
      a. Chilled Water: Green.
   3. Letter Color:
      a. Chilled Water: White.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for the following:
   1. Balancing Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
      c. Witness all high and medium pressure duct leakage tests, leakage tests on all field erected AHU's, all sectionally shipped factory fabricated AHU's and all low pressure duct mains, and low pressure duct risers.
   2. Balancing Hydronic Piping Systems:
      a. Constant-flow systems.
      b. Variable-flow systems.
   3. Steam systems.
   4. HVAC equipment quantitative-performance settings.
   5. Laboratory fume hood airflow balancing.
   6. Exhaust hood airflow balancing.
   7. Space pressurization testing and adjusting.
   8. Vibration measuring.
   9. Sound level measuring.
   10. Stair-tower pressurization testing and adjusting.
   11. Smoke-control systems testing and adjusting.
   12. Indoor-air quality measuring.
   13. Verifying that automatic control devices are functioning properly.
   14. Reporting results of activities and procedures specified in this Section.
   15. Domestic water recirculation.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

C. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

D. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

E. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

F. NEBB: National Environmental Balancing Bureau.

G. NC: Noise criteria.

H. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

I. RC: Room criteria.

J. Report Forms: Test data sheets for recording test data in logical order.

K. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

L. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

M. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

N. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

O. TAB: Testing, adjusting, and balancing.

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

Q. TAB Specialist: An entity engaged to perform TAB Work.

R. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

S. Test: A procedure to determine quantitative performance of systems or equipment.

T. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC, NEBB, or TABB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
    a. Submittal distribution requirements.
    b. The Contract Documents examination report.
    c. TAB plan.
    d. Work schedule and Project-site access requirements.
    e. Coordination and cooperation of trades and subcontractors.
    f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from TABB "Contractors Certification Manual."

E. Instrumentation Type, Quantity, and Accuracy: As described in ASHRAE 111, Section 5, “Instrumentation.”

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner may occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6 COORDINATION

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

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

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

1.7 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee 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. Guarantee 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.

B. Special Guarantee: Provide a guarantee on TABB forms stating that TABB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include 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

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one of the following:

1. Palmetto
2. E-nTech Independent Testing Services
3. EnTab

3.2 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.
   1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
   2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

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 supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section Metal Ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

G. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

J. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

K. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

L. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

M. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

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

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Sequence of operation for control modes is according to the Contract Documents.
   8. Controller set points are set at indicated values.
   9. Interlocked systems are operating.
   10. Changeover from heating to cooling mode occurs according to indicated values.

S. 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.

3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems and in this Section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets 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. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
4. Do not place holes in bottom of wet ductwork.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

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

3.5 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' "as-built" 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 outside-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 Division 23 Section "Metal Ducts."

3.6 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. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
2. Measure fan static pressures to determine actual static pressure as follows:
    a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

4. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
5. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
6. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
7. 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 will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates

full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at

fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.9 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect and comply with requirements in Division 23 Section "Hydronic Pumps."
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
    a. Monitor motor performance during procedures and do not operate motors in overload conditions.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

J. Check settings and operation of each safety valve. Record settings.

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.

3.11 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.12 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.

2. If water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
6. Capacity: Calculate in tons of cooling.
7. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.14 PROCEDURES FOR LABORATORY FUME HOODS

A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.

B. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.
1. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
2. For laboratory fume hoods designed with integral makeup air, measure, adjust, and record the exhaust and makeup airflow.

C. For laboratory fume hoods that are connected to centralized exhaust systems using automatic dampers, adjust the damper controller to obtain the indicated exhaust airflow.

D. After balancing is complete, do the following:
1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
2. Measure and record the face velocity across the open sash face area. Measure the face

velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter of the opening.

a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
b. Calculate and report the average face velocity by averaging all velocity measurements.
c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
d. If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.

3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

E. With the room and laboratory fume hoods operating at indicated conditions, perform an "as-installed" performance test of the laboratory fume hood according to ASHRAE 110. Test each laboratory fume hood(s) and document the test results. Use of a 3rd party agency is required as a subcontractor under the TAB agency.

3.15 PROCEDURES FOR EXHAUST HOODS

A. Measure, adjust, and record the airflow of each exhaust hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.

B. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.
2. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.

3.16 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.

1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
3. Test room pressurization first, then zones, and finish with building pressurization.

D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.17 PROCEDURES FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria:

1. Solid-state circuitry with a piezoelectric accelerometer.
2. Velocity range of 0.1 to 10 inches per second.
3. Displacement range of 1 to 100 mils.
4. Frequency range of at least 0 to 1000 Hz.
5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.

1. Use a calibrator provided with the vibration meter.
2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
   1. Turn off equipment in the building that might interfere with testing.
   2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp.

H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.
   1. Pumps:
      a. Pump Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Pump Base: Top and side.
      d. Building: Floor.
      e. Piping: To and from the pump after flexible connections.
   2. Fans and HVAC Equipment with Fans:
      a. Fan Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
      d. Equipment Base: Top and side.
      e. Building: Floor.
      f. Ductwork: To and from equipment after flexible connections.
      g. Piping: To and from equipment after flexible connections.
   3. Chillers and HVAC Equipment with Compressors:
      a. Compressor Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
      d. Equipment Base: Top and side.
      e. Building: Floor.
      f. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.

1. Verify that vibration isolation is installed in the required locations.
2. Verify that installation is level and plumb.
3. Verify that isolators are properly anchored.
4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.18 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm, use a windscreen on the microphone.

D. Perform sound-level testing after air and water balancing and equipment testing are complete.

E. Close windows and doors to the space.

F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

H. Take sound measurements at a height approximately 48 inches above the floor and at least 36 inches from a wall, column, and other large surface capable of altering the measurements.

I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
   1. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

K. Perform sound testing at 5 locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each

space type, select at least one location that is near and at least one location that is remote from the predominant sound source.

1. Private office.
2. Open office area.
3. Conference room.
4. Auditorium/large meeting room/lecture hall.
5. Classroom/training room.
6. Patient room/exam room.
7. Sound or vibration sensitive laboratory.
8. Hotel room/apartment.
9. Each space with a noise criterion of RC or NC 25 or lower.
10. Each space with an indicated noise criterion of RC or NC 35 and lower that is adjacent to a mechanical equipment room or roof mounted equipment.
11. Inside each mechanical equipment room.

3.19 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.20 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 10 percent of design.

B. Air inlets or Outlets for air change requirements for all procedure, treatment, exam and other patient areas:

1. Positive pressure room: Adjust supply inlets in space to within plus 0 to plus 10 percent (+0 to 10%) and outlets to minus 0 to minus 10 (-0 to 10%) percent of design.
2. Negative pressure room: Adjust supply inlets in space to within minus 0 to minus 10 percent (-0 to 10%) and outlets to plus 0 to plus 10 (+0 to 10%) percent of design.
3. Neutral pressure room: Adjust supply inlets and outlets in space to within plus or minus 10 percent of design, but as close to equal airflow as possible, within 5% of each other.

C. Other Air Outlets and Inlets in general and public areas: Adjust outlets and inlets in space to within plus or minus 10 percent of design.

D. Hydonic Systems Adjust to within plus or minus 10 percent of design.

3.21 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 systems' balancing devices. Recommend changes and additions to systems' 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 biweekly 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.

3.22 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. 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, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
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 firm 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, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms as required by AABC.
    a. Settings for outside-, return-, and exhaust-air dampers.

E. 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.

F. 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.

G. 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.

H. Instrument Calibration Reports:

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

I. Thermal performance of each item of heat exchange equipment. Agency is to perform measurements and certify to 5% thermal balance.

3.23 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Measure sound levels at two locations.
   e. Measure space pressure of at least 10 percent of locations.
   f. Verify that balancing devices are marked with final balance position.
   g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.

3. Architect shall randomly select measurements documented in the final report to be rechecked. The 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.
4. If the 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."
5. 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.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. 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 contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.24 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment and installation for HVAC systems and components, including control components for chillers, pumps, ductless split systems, exhaust fans, fume hoods, and laboratory equipment not supplied with factory-wired controls.

B. The Base Bid scope of work for this project is to reuse the existing Siemens Apogee BACNet control devices and infrastructure to the fullest extent possible. The control system shall be extension of the existing Siemens Building Automation System and all controllers and software shall match existing or be the latest version of existing.
   1. Existing control panels located in each air handling unit room and the boiler room on the first floor will be reused and any new control points for the new/replacement laboratory exhaust fans shown on the control schematics will be incorporated into such. Control components for existing laboratory exhaust fans (controllers, current relays, pressure sensors, airflow switches, etc.) deemed to be in good working order and suitable for reuse, are to be removed and re-installed for the new work per the exhaust fan control schematics.
   2. No splicing of existing floor level network will be allowed.
   3. Control graphics are to be updated to reflect the new HVAC equipment and existing fume hoods per the control schematics shown on the drawings. Graphics are to be coordinated with and reflect actual installed conditions, including current room names and numbers.
   4. Alternate Bid: Each new laboratory fume hood exhaust fan will be provided with a new variable frequency drive located in the mechanical room.

C. See "Sequences of Operation" for requirements that relate to this Section.

1.2 RELATED DOCUMENTS

A. Drawings and Specification Sections of the Contract, including General and Supplementary Conditions, apply to this Section.
   1. Division 01 – General and Special Requirements
   2. Division01 – Submittal Requirements
   3. Division01 – Materials and Equipment
   4. Division23 – Common Work Results for HVAC
   5. Division 23 – Sequences of Operation
   6. Division23 – Testing, Adjusting, and Balancing for HVAC
   7. Section 23 – Commissioning of HVAC
   8. Section 25 – Commissioning of Integrated Automation
   9. Division26 – General Electrical Provisions for Electrical Work

10. Division26 – Common Work Results for Electrical
11. Division26 – Low Voltage Electrical Power Conductors and Cables
12. Division26 – Hangers and Supports for Electrical Systems
13. Division26 – Raceway and Boxes for Electrical Systems
14. Division26 – Identification for Electrical Systems
15. Division 26 – Wiring Devices

1.3 ABBREVIATIONS

A. AAC: Advanced Application Controller

B. AHU: Air Handling Unit.

C. ALN: Automation Level Network

D. ASC: Application Specific Controller

E. ASHRAE: American Society of Heating Refrigerating and Air-Conditioning Engineers

F. BAS: Building Automation System

G. BC: Building Controller

H. BIBB: BACnet Interoperability Building Blocks

I. BIM: Building Information Modeling

J. BMS: Building Management System.

K. CFM: Cubic Feet per Minute.

L. DCIM: Data Center Infrastructure Management

M. DCV: Demand Controlled Ventilation

N. DDC: Direct digital controls

O. EIA: Electronics Industries Alliance

P. EMI: Electro-Magnetic Interference

Q. EP: Electric-to-Pneumatic

R. EPMS: Electrical Power Monitoring System

S. FAS: Fire Alarm System.

T. FLN: Floor Level Network

U. FCU: Fan Coil Unit

V. HMI: Human Machine Interface

W. HVAC: Heating, Ventilating and Air Conditioning.

X. IEEE: Institute of Electrical and Electronic Engineers

Y. I/O: Input/Output

Z. IP: Internet Protocol

AA. IT: Information Technology

BB. LAN: Local area network.

CC. LCD: Liquid Crystal Display

DD. LED: Light Emitting Diode

EE. MER: Mechanical Equipment Room.

FF. MLN: Management Level Network

GG. MS/TP: Master-slave/token-passing.

HH. NEMA: National Electric Manufacturers' Association

II. NFPA: National Fire Protection Association

JJ. OEM: Operator Equipment Manufacturer

KK. PC: Personal Computer

LL. PICS: Protocol Implementation Conformance Statement

MM. PID: Proportional Integral Derivative.

NN. POT: Portable Operators Terminal.

OO. RAM: Random Access Memory

PP. RFI: Radio Frequency Interference

QQ. RTD: Resistance Temperature Device

RR. SNMP: Simple Network Management Protocol

SS. TAB: Testing and Balancing

TT. TCP: Transfer Control Protocol

UU. UDP: User Datagram Protocol

VV. UL: Underwriters Laboratories

WW. UPS: Uninterruptable Power Supply

XX. VAV: Variable Air Volume

YY. VFD: Variable Frequency Drive.

ZZ. WAN: Wide Area Network.

1.4 DEFINITIONS

A. BACnet: An industry standard data communication protocol for Building Automation and Control Networks. Refer to the latest version of AHSRAE standard 135.

B. Scope Terminology
1. Provide = Furnish equipment, engineer, program and install
2. Furnish = Furnish equipment, engineer and program
3. Mount = securely fasten or pipe
4. Install = mount and wire
5. Wire = wire only

1.5 WORK INCLUDED

A. The BAS Contractor shall provide an extension of the existing onsite Siemens Insight BAS. The system shall be a complete and operational system that will perform the sequences of operation as described herein and as shown on the drawings.

B. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system controllers, logic controllers, and all input/output devices. Items of work included are as follows:
1. Provide a submittal that meets the requirements below for approval.
2. Coordinate installation schedule with the mechanical contractor and general contractor.
3. Provide installation of all panels and devices unless otherwise stated.
4. Provide power for panels and control devices unless otherwise stated.
5. Provide all low voltage control wiring for the DDC system.
6. Provide all final load side wiring to mechanical equipment and motors.

7. Provide all required loose starters/disconnects.
8. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
9. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
10. Participate in commissioning for all equipment that is integrated into the BAS (Refer to Commissioning sections of the equipment or systems in other parts of this specification.)
11. Provide testing, demonstration and training as specified below.

C. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.

1.6 SUBMITTALS

A. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submittals for the following items separately upon request:
1. Valve schedule and product data
2. Damper schedule and product data
3. Mounting and wiring diagrams for factory-installed control components
4. Thermostat locations

B. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:
1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.
3. Details of control panel faces, including sizes, controls, instruments, and labeling.
4. Schedule of dampers and actuators including size, leakage, and flow characteristics. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.
5. Schedule of valves including leakage and flow characteristics.
6. Written description of the Sequence of Operations.
7. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.
8. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
9. Starter and variable frequency drive wiring details of all automatically controlled motors.
10. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.

11. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
12. Submit BACnet Protocol Implementation Conformance Statements (PICS) for all direct digital controllers, software and other system components that will communicate on the BAS utilizing BACnet.

C. Submit a description of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

D. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.

E. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.

F. After the BAS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

G. Operation and Maintenance Data: In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. Product data with installation details, maintenance instructions and lists of spare parts for each type of control device.
2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.
4. Calibration records and list of set points.

1.7 PROJECT RECORD DOCUMENTS

A. Project Record Documents: Submit three (3) copies of record (as-built) documents upon completion of installation. Submittal shall consist of:
1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD compatible files in electronic format and as 11 x 17 inch prints.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements in the Control System Demonstration and Acceptance section of this specification.
3. Operation and Maintenance (O & M) Manual.
   a. As-built versions of the submittal product data.

b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
c. Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
d. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
f. Documentation of all programs created using custom programming language, including setpoints, tuning parameters, and object database.
g. Graphic files, programs, and database on electronic media.
h. List of recommended spare parts with part numbers and suppliers.
i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
j. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
k. Licenses, guarantees, and warranty documents for equipment and systems.

B. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
1. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.
2. Description of manual override operation of all control points in system.
3. BMS system manufacturers complete operating manuals.

C. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:
1. Complete as-built installation drawings for each building system.
2. Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.
3. Photographs and/or drawings showing installation details and locations of equipment.
4. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.
5. Parts list with manufacturer's catalog numbers and ordering information.
6. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.
7. Manufacturer's operation, set-up, maintenance, and catalog literature for each piece of equipment.
8. Maintenance and repair instructions.
9. Recommended spare parts.

D. Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum include the following:
   1. Complete programming manuals, and reference guides.
   2. Details of any custom software packages and compilers supplied with system.
   3. Information and access required for independent programming of system.

1.8 QUALITY ASSURANCE

A. Codes
   1. Perform all wiring in accordance with Division 26, NEC, local codes and Owner's requirements.
   2. 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.
   3. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
   4. Comply with ASHRAE 135-2010 BACnet: A Data Communication Protocol for Building Automation and Control Networks.
   5. Comply with ASHRAE 90.1-2013 Energy Standard for Buildings Except Low-Rise Residential Buildings.
   6. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems,
      a. Provide written approvals and certifications after installation has been completed.
   7. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
   8. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

B. Qualifications
   1. Installing contractor shall be in the business of installing and servicing DDC controls for mechanical systems, temperature and ventilation control, environmental control, lighting control, access and security, life safety and energy management as their primary business.
   2. Installer Qualifications: An experienced installer who is the authorized representative of the automatic control system manufacturer for both installation and maintenance of controls required for this Project.
   3. Engineering, drafting, programming, and graphics generation shall be performed by Siemens qualified engineers and technicians directly employed by the Building Automation System Contractor.
   4. Supervision, checkout and commissioning of the system shall be by the local branch engineers and technicians directly employed by the Building Automation System Contractor. They shall perform commissioning and complete testing of the BAS system.

C. The BAS contractor shall maintain a service organization consisting of factory trained service personnel and provide a list of ten (10) projects, similar in size and scope to this project, completed within the last five years.

D. Final determination of compliance with these specifications shall rest solely with the Engineers and Owner who will require proof of prior satisfactory performance.

E. For any BAS system and equipment submitted for approval, the BAS contractor shall state what, if any, specific points of system operation differ from these specifications.

F. All portions of the system must be designed, furnished, installed, commissioned, and serviced by manufacturer approved, factory trained employees.

G. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to building controllers, advanced application controllers, application specific, personal operator workstations and portable operator's terminals, to be connected and directly communicate with any new BAS system equipment without bridges, routers or protocol converters.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Deliver, store, protect, and handle products to site under provisions of the contract Documents. Coordinate all site delivers with Construction project Manager.

C. Protect products from construction operations, dust, and debris, by storing materials inside, protected from weather in a conditioned space.

1.10 COORDINATION

A. Coordinate IP drops, network connections, user interfaces, firewall, etc with Owner’s IT representative.

B. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.

C. Coordinate equipment with Division 28 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate power for control units and operator workstation with electrical contractor.

E. Coordinate equipment with provider of starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.

F. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.

G. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

H. Products Furnished but Not Installed Under This Section
   1. Hydronic and Refrigerant Piping accessories:
      a. Control Valves
      b. Temperature Sensor Wells and Sockets
      c. Pressure Sensor Wells and Sockets
      d. Flow Switches
      e. Flow Meters
      f. Differential Pressure Transmitters
   2. Sheet metal accessories
      a. Dampers
      b. Airflow Stations
      c. Terminal Unit Controls

I. Products Installed but Not Furnished Under This Section
   1. Refrigeration Equipment:
      a. Proof of flow pressure switches
   2. Rooftop Air Handling Equipment:
      a. Thermostats
      b. Duct Static Pressure Sensors

J. Products Integrated To but Not Furnished or Installed Under This Section
   1. Refrigeration Equipment
      a. Air Cooled Chiller

1.11 WARRANTY

A. Provide warranty per Division 20 Section “General Mechanical Requirements” and as supplemented in this section.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of 12 months from completion of system demonstration.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

D. During normal building occupied hours, failure of items that are critical for system operation shall be provided within 4 hours of notification from the Owner’s Representative.

E. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Siemens (APOGEE Series)
   2. Schneider Electric (TAC I/A Series)
   3. Distech Controls (BACnet Series)
   4. Alerton (Ascent Series)
   5. Johnson Controls (Facility Explorer Series)

B. Products by the DDC system manufacturer shall include user interface, controlling software, application programming language and equipment and application controllers. Sensors, actuators, valves dampers and other components may be manufactured by others as indicated.

C. Description: DDC system with BACnet system level protocol, having all points exposed to BACnet/IP, and Siemens APOGEE integration software framework. The control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories and software connected to distributed contollers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator- workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics. The control system shall be complete and fully operable.
   1. Siemens Apogee Licenses: All Apogee based systems shall have “open” licenses. The system shall not prevent anther vendor from accessing and modifying the software with proper admin login. Proprietary software shall not be required for future vendors to integrate with this system. No proprietary JAR (Java Archive) files or other drivers shall be used on the JACE hardware. If any hardware or software must be modified, repaired, or replaced in the future, any qualified vendor shall be able to do so without support of the system’s vendor.

D. The Building Automation System (BAS) contractor shall incorporate direct digital control (DDC) for central plant equipment, building ventilation equipment, supplemental heating and cooling equipment, and terminal units.

E. The control system for this project shall be an extension of the Owner’s existing Siemens Insight Building Automation System and all controllers and software shall match existing or be latest version of existing.

F. Provide networking to new DDC equipment using industry accepted communication standards. System shall utilize BACnet communication according to ANSI/ASHRAE standard 135-2010 for interoperability with smart equipment, for the main IP communication trunk to the BAS Server

and for peer-to-peer communication between DDC panels and devices. The system shall not be limited to only standard protocols, but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

G. Provide standalone controls where called for on the drawings or sequences.

2.2 BUILDING AUTOMATION SYSTEM NETWORK

A. All networked control products provided for this project shall be comprised of an industry standard open protocol internetwork. Communication involving control components (i.e. all types of controllers and operator interfaces) shall conform to ASHRAE 135-2010 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.
   1. Software applications, features, and functionality, including administrative configurations, shall not be separated into several network control engines working together.

C. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.

D. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

E. Any break in Ethernet communication between the server and standard client workstations on the Primary Network shall result in a notification at each workstation.

F. The network architecture shall consist of three levels of networks:
   1. The Management Level Network (MLN) shall utilize BACnet/IP over Ethernet along with other standardized protocol, such as web services, html, JAVA, SOAP, XML, etc., to transmit data to non-BAS software applications and databases. The BAS Server and Operator Workstations shall reside on this level of the network architecture.
   2. The Automation Level Network (ALN) shall utilize BACnet/IP over Ethernet. It shall connect BACnet Building Controllers to the BAS Server and Operator Workstations. Controllers for central plant equipment and large infrastructure air handlers shall reside on the ALN backbone BACnet/IP network. Provide network media converters, routers and switches as necessary for a complete network.
   3. The Floor Level Network shall utilize BACnet/IP over Ethernet or BACnet MS/TP over RS-485 to connect all of the DDC-controlled terminal heating and cooling equipment on a floor or in a system that are controlled with BACnet Advanced Application Controllers or BACnet Application Specific Controllers. FLN devices are networked to a router that connects to the Automaton Level Network backbone.

G. The primary backbone network between the building level controllers, BAS Server and Operator Workstations shall be based upon BACnet/IP. Ethernet Network switches shall be strategically placed through the building to cover several floors or several mechanical rooms that are within 300 ft wiring-feet of each other.

H. Use fiber optic cabling for all Ethernet runs longer than 300 ft.

I. Provide a router for each RS-485 subnetwork to connect them to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet. Routers shall be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

J. The Building Level Controllers shall be able to support subnetwork protocols that may be needed depending on the type of equipment or application. Subnetworks shall be limited to:
   1. BACnet MS/TP
   2. Apogee FLN
   3. Modbus

K. BACnet MSTP Setup rules
   1. Addressing for the MSTP devices shall start at 00 and continue sequentially for the number of devices on the subnetwork.
   2. No gaps shall be allowed in the addresses.
   3. Set the MaxMaster property to the highest address of the connected device.
   4. MaxMaster property shall be adjusted when devices are added to the subnetwork.

L. 12Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for the internetwork.

M. 3Controllers and software shall be BTL listed at the time of installation.

N. The system shall meet 4peer-to-peer communication services such that the values in any one BACnet Building Controller or BACnet Advanced Application Controller can be read or changed from all other controllers without the need for intermediary devices. The software shall provide transparent transfer of all data, control programs, schedules, trends, and alarms from any one controller through the internetwork to any other controller, regardless of subnetwork routers.

O. Systems that use variations of BACnet using Point-to-Point (PTP) between controllers, gateways, bridges or networks that are not peer-to-peer are not allowed.

P. Remote Communications: Provide a TCP/IP compatible communication port for connection to the Owner’s network for remote communications. Provide coordination with the Owner for addressing and router configuration on both ends of the remote network.

Q. The system shall be installed with a 10% spare capacity on each subnetwork for the addition of future controllers.

R. On each floor, wing or major mechanical room provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

S. Distributed Control Requirements:
1. The loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.
2. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
4. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarms to multiple operator workstations without dependence upon a central or intermediate processing device.
5. Operators shall have the ability to make database changes at the central system server while operator workstations are on-line without disrupting other system operations.
6. The DDC control panel shall be mounted in the same mechanical room as the equipment being controlled, or an adjacent utility room.
7. Multiple systems can be programmed on the same controller as long as they are in the same room. Systems on separate floors shall have separate controllers.
8. VAV boxes subnetworks shall be connected to the AHU controller that feeds those boxes. If multiple subnetworks are needed, then the VAV shall be grouped into subnetworks in an orderly method, such as per floor, per wing, etc.
9. Remote sensors shall be wired to the control panel of the equipment it is controlling, not across the network.
10. Signals to remote motor control centers shall be hard wired to the control panel, not across the network.

2.3 BUILDING AUTOMATION SYSTEM SERVER HARDWARE

A. BAS Server application and database shall be an extension of the existing Siemens Insight server.

2.4 BACNET ADVANCED WORKSTATION SOFTWARE

A. Interface Description
1. The software shall provide, as a minimum, the following functionality:

a. Real-time graphical viewing and control of the BMS environment.
b. Reporting of both real-time and historical information.
c. Scheduling and override of building operations.
d. Collection and analysis of historical data.
e. Point database editing, storage and downloading of controller databases.
f. Configuration of and navigation through default and personalized hierarchical “tree” views that include workstation and control system objects.
g. Event reporting, routing, messaging, and acknowledgment.
h. Definition and construction of dynamic color graphic displays.
i. Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
j. On-screen access to User Documentation, via online help or PDF-format electronic file.
k. Automatic database backup at the operator interface for database changes initiated at Building Controllers.
l. Display dynamic trend data graphical plot.
    1) Must be able to run multiple plots simultaneously.
    2) Each plot must be capable of supporting 10 pts/plot minimum.
    3) Must be able to command points from selection on dynamic trend plots.
    4) Must be able to plot real-time data without prior configuration.
    5) Must be able to plot both real-time and historical trend data simultaneously.
m. Program editing
n. Transfer trend data to third-party spreadsheet software
o. Scheduling reports
p. Operator Activity Log

2. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications.
3. Users must be able to build multiple, separate, personalized hierarchical “tree” views that represent the workstation, control systems, geographical facility layouts, and mechanical equipment relationships.
4. 256-character point identification (names) must be supported to provide clearly descriptive identification.
5. On-line help must be available.
6. The user interface shall display relevant information for a selection in multiple panes of a single window without the need for opening multiple overlapping windows on the desktop
7. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.
8. Software navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded links to graphics, documents, drawings, trends, schedules, as well as external documents (.doc, .pdf, .xls, etc.) or web addresses that are related to any selected object.
9. Primary selection of objects in the operator interface software shall be available from user defined hierarchical Views, from graphics, or from events in an Event List.

10. Secondary selection of objects in the operator interface software shall be available from links to any objects or external documents related to the primary selection.
11. Links to information related to any selected objects shall be displayed in a consistent manner and automatically defined based on where an object is used in the system.
12. The operator workstation shall be capable of displaying web pages and common document formats (.doc, .xls, .pdf) within the operator workstation application.
13. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously.
14. System database parameters shall be stored within an object-oriented database.
15. Standard Windows applications shall run simultaneously with the BMS software.
16. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.
17. Provide automatic backup and restore of all Building Controller databases on the workstation hard disk.
18. System configuration, programming, editing, graphics generation shall be performed on-line from the operator workstation software.
19. User shall be able to edit point configuration of any configurable BACnet point that resides in a devices that supports external editing.
20. The software shall also allow the user to configure the alarm management strategy for each point.
21. Users shall have the ability to view the program(s) that is\are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

B. Certifications and Approvals
   1. BAS software shall have been tested against the following norms and standards:
      a. BACnet Revision 1.13, certified by BACnet Testing Laboratory as BACnet Advanced Workstation Software (BTL B-AWS)
      b. IT security compliant with the ISA-99/IEC 62443 Security Level: SL1
      c. OPC DA V2.05a and V3.0 Server, certified by the OPC Foundation certification program
      d. UL-listed to UL864 9th edition Standard for Control Units and Accessories (when installed on a UL-approved computer)

C. Client-Server Connectivity
   1. Client sessions must be allowed to run on the server and on other devices connected to the server via Intranet, Extranet, or Internet connections.
   2. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support remote access features.
   3. The following client options must be supported
      a. Installed Client.
         1) Software application installed from installation media on to the client machine.
         2) Installed client software must be configurable to allow it to run in a Closed Mode such that the BAS software can lock down the client machine and

prevent users without permission from minimizing the application or running other Windows applications that might cover the BAS software interface.

3) Communication between the server and Installed Clients must be monitored so that any break in communication between the server and an installed client results in notification at the Server and Installed Client machine

4) Installed client machines communicate directly with the BAS server

b. Web Client.

1) Software that runs in a browser on the client machine as a Full Trust client application.

2) Connected to the BAS software server via Microsoft IIS Server.

c. Windows App.

1) Software application downloaded from the BAS server to run on the client machine like an installed application

2) Application must be automatically updated whenever new apps are available at the server.

3) Connected to the BAS software server via Microsoft IIS Server.

4. Each of the client options shall provide the same functionalities including operation and configuration capabilities.

D. Access Rights and User Privileges

1. Access to any client user session must be password protected.
2. Users shall be able to create local user accounts specific to the application software.
3. Users shall be able to link application user accounts to Active Directory user accounts for consistent management with domain user accounts.
4. Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned user name and password.
5. Operator privileges shall follow the operator to any workstation logged onto.
6. The administrator or manager shall be able to further limit operator privileges based on which console an operator is logged on to.
7. The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application.

E. Activity Logging

1. The operator interface software shall maintain a log of the actions of each individual operator.
2. The software shall provide an application that allows querying based on object name, operator, action, or time range.
3. The software shall provide the ability to generate reports showing operator activity based on object name, operator, action, or time range.

F. Graphics Application

1. All graphics shall be available with the same look and functionality whether they are displayed at an installed client console or in a browser.
2. User shall be able to add/delete/modify system graphics for floor plan displays and system schematics for each piece of mechanical equipment (including, air handling units, chilled water systems, hot water boiler systems, and exhaust fans) from standard user interface without the need of any external or specialized tools.
3. The software shall include all necessary tools and procedures for the user to create their own graphics.
4. The software shall provide the user the ability to display real-time point values by animated motion or custom picture control visual representation.
5. The software shall provide animation that depicts movement of mechanical equipment, or air or fluid flow.
6. The software shall provide users the ability to depict various positions in relation to assigned point values or ranges.
7. The software shall provide the ability to add custom gauges and charts to graphic pages.
8. The software must include a library of at least 400 standard control application graphics and symbols for visualizing common mechanical systems, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams, piping, and laboratory symbols.
9. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.
10. The Graphics application shall be capable of automatically assigning the appropriate symbol for an object (point) selected to be displayed on the graphic based on what the object represents (fan, duct sensor, damper, etc.) when the object is placed on a graphic.
11. The Graphics application shall allow a user to manually override the automatically assigned symbol for an object when a different symbol is desired.
12. The user shall have the ability to add custom symbols to the symbol library.
13. The software shall permit the importing of AutoCAD or scanned pictures for use in graphics.
14. Graphics must be automatically associated to any points or system objects that are rendered on the graphic, so that selection of a system object will allow a user to simply navigate to any associated graphic, without the need for manual association.
15. The software must allow users to command points directly off graphics application.
16. Graphic display shall include the ability to depict real-time point values dynamically with text or animation.
17. Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure
18. Graphics viewing shall include dynamic pan zoom capabilities.
19. Graphics viewing shall include the ability to switch between multiple layers with different information on each layer.
20. Graphics shall include a decluttering capability that allows layers to be programmatically hidden and displayed based on zoom level.

21. Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
22. The software must provide the ability to create dashboard views consisting of gauges and charts that graphically display system and/ or energy performance.

G. System Performance
1. Comply with the following performance requirements:
    a. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 5 seconds.
    b. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.
    c. Object Command: Reaction time of less than 5 seconds between operator command of a binary object and device reaction.
    d. Object Scan: Transmit change of state and change of analog values to control units or workstation within 5 seconds.
    e. Alarm Response Time: Annunciate alarm at workstation within 2 seconds. Multiple workstations must receive alarms within five seconds of each other.
    f. Program Execution Frequency: Programmable controllers shall execute DDC PI control loops, and scan and update process values and outputs at least once per second.
    g. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
        1) Water Temperature: Plus or minus 1 deg F.
        2) Water Flow: Plus or minus 5 percent of full scale.
        3) Water Pressure: Plus or minus 2 percent of full scale.
        4) Space Temperature: Plus or minus 1 deg F.
        5) Ducted Air Temperature: Plus or minus 1 deg F.
        6) Outside Air Temperature: Plus or minus 2 deg F.
        7) Dew Point Temperature: Plus or minus 3 deg F.
        8) Temperature Differential: Plus or minus 0.25 deg F.
        9) Relative Humidity: Plus or minus 2 percent.
        10) Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
        11) Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
        12) Air Pressure (Space): Plus or minus 0.01-inch wg.
        13) Air Pressure (Ducts): Plus or minus 0.1-inch wg.
        14) Electrical: Plus or minus 5 percent of reading.

H. Reports
1. The software must allow reports shall be executed on demand.
2. The software must allow reports shall be executed via pre-defined schedule.
3. As a minimum, the system shall allow the user to easily obtain the following types of reports:
    a. A general listing of all or selected points in the network
    b. A status report showing present value and alarm status
    c. List of all points currently in alarm

d. List of all points currently in override status
e. List of all disabled points
f. System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
g. List of alarm strategy definitions
h. List of Building Control panels
i. Point totalization report
j. Point Trend data listings
k. Initial Values report
l. User activity report
m. Event history reports

I. Scheduling
1. The software shall provide a calendar type format for simplification of time and date scheduling and overrides of building operations.
2. The software shall support the definition of BACnet schedules that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Fully support all BACnet Schedule, Calendar, and Command objects.
   b. Daily and Weekly schedules
   c. Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights)
   d. Ability to schedule for a minimum of up to ten (10) years in advance.
3. The software shall support the definition of schedules that are configured and executed to run at the workstation, to support scheduling of workstation software activities and to support field systems that do not include internal scheduling mechanisms. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Schedule predefined reports
   b. Schedule Trend collections
   c. Schedule automated system backups
   d. Schedule commands to be sent to field panels
   e. Daily and weekly schedules
   f. Setting up and executing Holiday schedules
   g. Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights)
   h. Ability to schedule for a minimum of up to ten (10) years in advance.
4. The software shall support the definition of Apogee Equipment Schedules Objects that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Apogee equipment schedule Zones
   b. Apogee equipment schedule Events
   c. Configuration of Daily, Weekly, Monthly schedules

d. Configuration of Replacement Days

5. The software shall provide the ability for users to override regular weekly schedules through menu selection, graphical mouse action or function key.
6. The software shall provide a timeline view, showing the results of any number of combined selected workstation and field panel controller schedules for an overview of facility operation.

J. Trending

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time.
2. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable.
3. Trend data shall be collected and stored on hard disk for future diagnostics and reporting.
4. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of equipment.
5. System shall support trending in the same device as the monitor point or in an external device.
6. The software must support configuration of panels that have a trending level threshold, above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space).
7. Trend data reports shall be provided to allow the user to view all trended point data.
8. Trend data reports may be customized to include individual points or predefined groups of selected points.
9. The software shall allow the user to view real-time trend data on trend graphical plot displays.
    a. A minimum of ten points may be plotted
    b. A combination of real-time and historical data may be plotted
    c. Dynamic graphs shall continuously update point values
    d. At any time the user may redefine sampling times or range scales for any point
    e. The user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis
    f. Exact point values may be viewed on the Trend plot
    g. Trend graphs may be printed
    h. Operator shall be able to command points by selecting them on the trend plot. Operator shall be able to zoom in on a specific time range within a plot.
    i. The Trend Viewer must allow users to configure separate left and right axis for easier differentiation of point values.
    j. The Trend Viewer must allow users to display historical data for the same group of points at different times simultaneously for easy comparison of system behavior over time.

K. Event Management

1. Event Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each event: name, value, event time and date, event status, priority, acknowledgement information, and alarm count.
2. Only events for which the logged on user has privileges to view shall be displayed on each workstation.
3. The software shall provide the ability to users to limit the list of events displayed at each workstation (e.g. only show fire events at this workstation, no matter who is logged on)
4. Each event shall have the ability to sound an audible notification based on the category of the event.
5. Event List shall have the ability to list and sort the events based on event status, point name, ascending or descending activation time.
6. Directly from the Event List, the user shall have the ability to acknowledge, silence the event sound, print, or erase each event.
7. The interface shall provide the option to inhibit the erasing of active acknowledged events, until they have returned to normal status.
8. The user shall have the ability to navigate to all information related to a selected point in order to command, launch an associated graphic or trended graphical plot, or run a report on a selected point directly from the Event List.
9. Each event shall have a direct link from the Event List to further user-defined point informational data.
10. The user shall have the ability to also associate real-time electronic annotations or notes to each event.
11. Software shall provide the option to configure detailed operating procedures that guide a user through predetermined standard operating procedures for handling critical events. Users shall be able to log completion of each operating step as it is performed.

L. External Data Access
1. The software shall provide the ability to expose configuration properties and real-time values through CSV files, OPC DA, OPC UA, or REST-based Web Services.
2. The software shall provide the ability for external applications to change configuration and real-time values through OPC DA, OPC UA, or REST-based Web Services.
3. The software shall provide the ability for external applications to access historical Trend data through CSV files or REST-based Web Services.
4. External data access must be secured using the level of permissions configured for users and operator workstations.
5. Web service interfaces must allow for exchanging data (object's values, events and trend series) between workstation and external applications such as facility management systems, enterprise applications, mobile applications or other value-added services.
6. Documentation describing web services interfaces must be included to allow external developers to write applications that leverage the data exchange.

M. Licensing
1. Software licensing must be allowed to be bound to a dongle or to physical PC hardware.
2. User licenses from all client types shall be from a common pool of client licenses. Licenses for installed and browser-based clients shall not be in separate pools.
3. Provide the number of client licenses as called for here or in the Sequence of Operations.

N. Data Security
   1. The BAS software must allow that all communication paths between clients and the server are encrypted and protected against replay attacks as well as data manipulation.
   2. Any runtime data transfer between the system server and Web Server (IIS) must be allowed to be encrypted by Desigo CC.
   3. Communication between any Web Server (IIS) and the Web Clients must be allowed to be encrypted.
   4. Passwords must be handled with encrypted storage and transmission
   5. The software must support the use of public domain algorithms for cryptographic functions, including AES, DiffieHellmann, RSA, and SHA-2. No self-coded algorithms shall be allowed.
   6. All symmetrical encryption must use 256 bit AES or stronger.
   7. All asymmetrical encryption must use 2048 bit or stronger.
   8. The software must support the use of commercial certificates for securing client-server communications.
   9. The software must support the use of self-signed certificates to allow local deployments without the overhead of obtaining commercial certificates.
   10. When using self-signed certificates, the owner of the Desigo CC system is responsible for maintaining their validity status, and for manually adding them to and removing them from the list of trusted certificates.
   11. The BAS software shall be compatible with the following Virus Scanners:
      a. Kaspersky
      b. Avira
      c. McAfee
      d. Bitdefender
      e. TrendMicro Office Scan

O. Virtualization
   1. The BAS software must be compatible with following Virtualization software packages:
      a. VMware®:
         1) Virtualization platform: VSphere 6.0 or higher
         2) Fault-tolerant software: ESXi 6.0b managed by VCenter Server Appliance v6.0.0 or higher
      b. Stratus®:
         1) Virtualization platform: KVM for Linux CentOS v7.0 or higher
         2) Fault-tolerant software: everRun Enterprise 7.2 or higher
         3) Virtualization platform: Citrix XenServer 6.0.2 or higher
         4) Fault-tolerant software: everRun MX 6.2 or higher

P. Subsystem Connectivity
   1. The BAS application software must be capable of connecting simultaneously to multiple control systems and data sources.
   2. Interface software shall simultaneously communicate with and share data between multiple Ethernet-connected building level networks.
   3. The BAS application software must support the following standard protocols:
      a. BACnet IP (standard Revision 1.13)

b. OPC (OLE for Process Control) OPC DA 2.05, 3.0
c. Modbus TCP
d. SNMP (Agent V1 and V2)
e. Siemens Apogee P2
f. Siemens XNET

4. Any break in system controller communication must result in a notification at the server.

Q. BACnet

1. The Operator Workstation Software shall be capable of BACnet IP communications.
2. The Operator Workstation Software shall have demonstrated interoperability during at least one BTL Interoperability Workshop.
3. The Operator Workstation Software shall have demonstrated compliance to BTL B-AWS device classification through BTL listing as specified in ANSI/ASHRAE 135 under revision 1.13 or higher.
4. The BAS software shall meet the BACnet device profile of an Advanced Workstation Server (B-AWS) and Operator Workstation (B-OWS) and shall support the following BACnet BIBBs:
   a. Data Sharing
      1) DS-RP-A Data Sharing-ReadProperty-A
      2) DS-RP-B Data Sharing-ReadProperty-B
      3) DS-RPM-A Data Sharing-ReadPropertyMultiple-A
      4) DS-RPM-B Data Sharing-ReadPropertyMultiple-B
      5) DS-WP-A Data Sharing-WriteProperty-A
      6) DS-WP-B Data Sharing-WriteProperty-B
      7) DS-WPM-A Data Sharing-WritePropertyMultiple-A
      8) DS-COV-A Data Sharing-ChangeofValue-A
      9) DS-COVP-A Data Sharing – ChangeofValueProperty-A
      10) DS-V-A Data Sharing - View - A
      11) DS-AV-A Data Sharing - Advanced View - A
      12) DS-M-A Data Sharing - Modify - A
      13) DS-AM-A Data Sharing - Advanced Modify - A
   b. Scheduling
      1) SCHED-VM-A Scheduling-View and Modify-A
      2) SCHED-AVM-A Scheduling-Advanced View and Modify-A
      3) SCHED-WS-A Scheduling-Weekly Schedule-A
   c. Alarm and Event Management
      1) AE-N-A Alarm and Event-Notification-A
      2) AE-ACK-A Alarm and Event-ACK-A
      3) AE-LS-A Alarm and Event-LifeSafety - A
      4) AE-VM-A Alarm and Event Management - View and Modify - A
      5) AE-AVM-A Alarm and Event Management - Advanced View and Modify - A
      6) AE-VN-A Alarm and Event Management - View Notifications - A
      7) AE-AVN-A Alarm and Event Management - Advanced View Notifications - A
   d. Trending
      1) T-V-A Trending-Viewing and Modifying Trends-A
      2) T-ATR-A Trending-Automated Trend Retrieval-A

3) T-AVM-A Trending-Advanced View and Modify -A

e. Network Management
   1) NM-CE-A Network Management-Connection Establishment-A

f. Device Management
   1) DM-DDB-A Device Management-Dynamic Device Binding-A
   2) DM-DDB-B Device Management-Dynamic Device Binding-B
   3) DM-DOB-A Device Management-Dynamic Object Binding-A
   4) DM-DOB-B Device Management-Dynamic Object Binding-B
   5) DM-DCC-A Device Management-DeviceCommunicationControl-A
   6) DM-TM-A Device Management-Text Message-A
   7) DM-MTS-A Device Management-Manual Time Synchronization-A
   8) DM-ATS-A Device Management-Automatic Time Synchronization-A
   9) DM-TS-A Device Management-TimeSynchronization-A
   10) DM-UTC-A Device Management-UTCTimeSynchronization-A
   11) DM-RD-A Device Management-ReinitializeDevice-A
   12) DM-BR-A Device Management-Backup and Restore-A
   13) DM-LM-A Device Management-List Manipulation-A
   14) DM-LM-B Device Management-List Manipulation-B
   15) DM-OCD-A Device Management-Object Creation and Deletion-A
   16) DM-ANM-A Device Management-Automatic Network Mapping-A
   17) DM-ADM-A Device Management-Automatic Device Mapping-A

5. The BAS Server and Workstations shall support the following Data Link Layers:
   a. BACnet IP Annex J
   b. BACnet IP Annex J Foreign Device
   c. ISO 8802-3, Ethernet (Clause 7)
6. The BAS Server and Workstations shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
7. The BAS Server and Workstations shall support transmitting and receiving segmented messages.
8. The BAS Server and Workstation shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

2.5 DIRECT DIGITAL CONTROLLER SOFTWARE

A. Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.

B. The software program shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

C. The software shall be provided with an interactive HELP function to assist operators with syntax, abbreviations, commands and saving programs.

D. Point naming and communication format:
   1. All points, panels, and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
   2. All digital points shall have a consistent, user-defined, two-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).
   3. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.

E. System Security
   1. User access shall be secured using individual security passwords and user names.
   2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
   3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
   4. User Log On/Log Off attempts shall be recorded.
   5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
   6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the DDC controller software.

F. User Defined Control Applications: The applications software shall program DDC routines to meet the sequences of operations.
   1. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
   2. The Building Controllers shall have the ability to perform the following pretested control algorithms:
      a. Two position with differential control and time delays
      b. Floating control
      c. Proportional control
      d. Proportional plus integral control
      e. Proportional, integral, plus derivative control

f. Automatic tuning of control loops
g. Model-free adaptive control
h. Start Stop Time Optimization

3. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
4. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

G. Peer-to-peer access to other DDC controllers
1. It shall be possible to use any actual or virtual point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
2. Any process shall be able to issue commands to points in any and all other controllers in the system.
3. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of an advanced annunciation feature, such as:
a. Generate a report
b. Annunciate an alarm
c. Issue a text message or email

H. Alarm Management
1. Alarm management shall be provided within the controller software to monitor and direct alarm information to operator devices.
2. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic, and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device, or communications with other panels on the network.
3. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
4. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
5. Binary Alarms. Each binary alarm object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
6. Analog Alarms. Each analog alarm object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
7. All alarm shall include the point's user-defined language description and the time and date of occurrence.
8. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print reports, be logged in the event log, generate custom messages, and display graphics.
9. The user shall be able to add a 200-character alarm message to each alarm point to more fully describe the alarm condition or direct operator response. Each Building Controller

shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.

10. Operator-selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.
11. An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.

I. Scheduling:
   1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
   2. Schedules shall reside in the building controller and shall not rely on external processing or network.
   3. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
   4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
   5. The operator shall be able to define the following information:
      a. Time, day
      b. Commands such as on, off, auto, etc.
      c. Time delays between successive commands.
      d. There shall be provisions for manual overriding of each schedule by an authorized operator.
   6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
      a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
      b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

J. Peak Demand Limiting (PDL):
   1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
   2. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
   3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
   4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
   5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

K. Temperature-compensated duty cycling
   1. User defined conditions shall be able to initiate a Duty Cycle Control Program.
   2. The Duty Cycle Control Program (DCCP) shall be configured to periodically stop and start loads according to various patterns.
   3. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

L. Automatic Daylight Savings Time Switchover. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

M. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

N. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

O. Control Loop Algorithm
   1. Provide a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be accessible from the operator workstation.

P. Adaptive Loop Tuning
   1. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.
   2. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
   3. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
      a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
      b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

Q. Logic programming: Provide a software routine that can build ladder logic to control using many conditional statements.
   1. The logic programming syntax shall be able to combine ladder logic with other software features, such as combining status, scheduling, PDL and alarm conditions into one conditional decision.
   2. Logic programming shall be able to reference conditions in any other controller in the system.

R. Staggered Start:
   1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable in an application and shall not require written scripts or ladder logic.
   2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

S. Totalization Features:
   1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
   2. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.
   3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

T. Data Collection:
   1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
   2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
   3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
   4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.
   5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
   6. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

2.6 BACNET BUILDING CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher-level computer or another controller for operation.

B. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:
   1. Data Sharing
      a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
      b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
      c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
      d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
      e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
      f. Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A,B)
   2. Scheduling
      a. Scheduling-Internal- Execute (SCHED-I-B)
      b. Scheduling-External- Execute (SCHED-E-B)
   3. Trending
      a. Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)
      b. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
      c. Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)
      d. Trending-Automated Trend Retrieval- Execute (T-ATR-B)
   4. Network Management
      a. Network Management-Connection Establishment- Initiate (NM-CE-A)
   5. Alarming
      a. Alarm and Event-Notification- Initiate (AE-N-A)
      b. Alarm and Event-Notification Internal- Execute (AE-N-E-B)
      c. Alarm and Event-Notification External- Execute (AE-N-E-B)
      d. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
      e. Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)
      f. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A,B)
      g. Alarm and Event –Information- Initiate, Execute (AE-ESUM-A,B)
   6. Device Management
      a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
      b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
      c. Device Management-Device Communication Control- Execute (DM-DCC-B)
      d. Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
      e. Device Management-Text Message- Initiate, Execute (DM-TM-A,B)
      f. Device Management-Time Synchronization- Execute (DM-TS-B)
      g. Device Management-Reinitialize Device- Execute (DM-RD-B)
      h. Device Management-Backup and Restore- Execute (DM-RD-B)
      i. Device Management-List Manipulation- Execute (DM-RD-B)
      j. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)
   7. The Building Level Controller shall support the following Data Link Layers:
      a. BACnet IP Annex J

b. BACnet IP Annex J Foreign Device
c. MS/TP Master (Claus 9)

8. The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable
9. The Building Level Controller shall support transmitting and receiving segmented messages.
10. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
11. The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

C. This level of controller shall be used for the following types of systems:
1. Chiller plant systems
2. Heating plant systems
3. Pumping systems
4. VAV air handlers
5. Air handlers over 15,000 cfm
6. Systems with over 24 input/output points
7. Rooftop systems

D. Computing power and memory minimum:
1. A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.
2. Inputs shall be 16-bit minimum analog-to-digital resolution
3. Outputs shall be 10-bit minimum digital-to-analog resolution
4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.
5. Real time clock and battery
6. Data collection/ Data Trend module sized for 10,000 data samples.
7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

E. Onboard or Modular hardware and connections:
1. Primary Network communication module, if needed for primary network communications.

2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port

F. Input and Output Points Hardware
1. Input/output point modules as required including spare capacity.
2. Input/output point modules shall have removable terminal blocks.
3. Monitoring of the status of all hand-off-auto switches.
4. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
5. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
6. Graduated intensity LEDs or analog indication of value for each analog output.
7. Optional HOA (hand-off-auto module) with software configurability and LED status indicators.

G. Code compliance
1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

H. Accessories:
1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

I. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

J. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

K. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

L. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

M. Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.

N. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

O. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

P. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

Q. Environment.
1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
4. Controller hardware shall be optionally suitable for rooftop environments.

R. Immunity to power and noise.
1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. 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).
3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
    a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
    b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
    c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
    d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
4. Isolation shall be provided at all Building Controller’s AC input terminals to suppress induced voltage transients consistent with:
    a. IEEE Standard 587 1980
    b. UL 864 Supply Line Transients
    c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.7 BACNET ADVANCED APPLICATION CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Unitary Equipment Controller (PXCxx-UCM).

C. The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004 or ANSI/ASHRAE 135-2008. Supported BIBBS shall include:
   1. Data Sharing
      a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
      b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
      c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
      d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
      e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
   2. Scheduling
      a. Scheduling-Internal- Execute (SCHED-I-B)
   3. Trending
      a. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
      b. Trending-Automated Trend Retrieval- Execute (T-ATR-B)
   4. Network Management
      a. Network Management-Connection Establishment- Initiate (NM-CE-A)
   5. Alarming
      a. Alarm and Event-Notification Internal- Execute (AE-N-I-B)
      b. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
      c. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-B)
      d. Alarm and Event –Information- Execute (AE-INFO-B)
   6. Device Management
      a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
      b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
      c. Device Management-Device Communication Control- Execute (DM-DCC-B)
      d. Device Management-Time Synchronization- Execute (DM-TS-B)
      e. Device Management-Reinitialize Device- Execute (DM-RD-B)
      f. Device Management-Backup and Restore- Execute (DM-BR-B)
      g. Device Management-List Manipulation- Execute (DM-LM-B)
      h. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)
   7. The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
      a. Calendar – Creatable, Deletable
      b. Command – Creatable, Deletable
      c. Event Enrollment – Creatable, Deletable

d. Notification Class – Creatable, Deletable
e. Schedule - Creatable, Deletable

8. The Advanced Application Controller shall support transmitting and receiving segmented messages.

D. Communication:
1. BAS Network: The Advanced Application Controller shall support the following Data Link Layers:
a. MS/TP Master
2. Serial Communication: Temporary use of portable devices shall not interrupt the BAS communication, nor the normal operation of permanently connected printers or terminals.
a. Provide at least one EIA-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals.
b. A USB port shall alternatively be available to support local HMI tools connection.

E. Software
1. The software programs specified in this section shall be provided as an integral part of Advanced Application Controllers and shall not be dependent upon any higher level computer or another controller for execution.
2. Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to
a. scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides
b. automatic daylight savings time switch over
c. night setback control
d. economizer switch over using enthalpy, dry bulb or a combination
e. peak demand limiting,
f. temperature-compensated duty cycling
g. heating/cooling interlock
h. supply temperature reset
i. priority load shedding
j. power failure restart
3. The software shall have a routine for automatic tuning of control loops
4. System Security in the Field Panel
a. User access shall be secured using individual security passwords and user names.
b. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
c. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
d. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.
5. User Defined Control Applications:
a. Controllers shall be fully-programmable. Controllers shall execute custom, job-specific sequences to automatically perform calculations and special control

routines. Factory installed or pre-configured sequences shall only be allowed if they exactly match the sequence specified herein.

b. Programs shall combine control logic, control loop algorithms, and energy management routines

c. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

d. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

F. Adaptive Loop Control.

1. Each AAC controller shall come standard with an Adaptive Control Loop Algorithm
   a. Tuning parameter shall automatically adjust for non-linear applications
2. Model-Free Adaptive (MFA) algorithm
   a. The algorithm shall not require modeling of the non-linear system in order to maintain control at all points of the non-linear load.
   b. The controlled variable, setpoint, and weighting parameters shall be user-selectable.
3. Output shall be analog or shall stage a series of outputs.
4. Adaptive Control shall take the place of Proportional, Proportional + Integral, and PID type algorithms for non-linear applications. Adaptive Control routines shall :
   a. Improve response time
   b. Improve System efficiency
   c. Improve Stability
   d. Result in Consistent outputs
   e. Reduce cycling and repositioning
   f. Reduce wear and tear on actuators
5. Adaptive control shall auto-adjust to compensate for
   a. mode changes
   b. load changes
   c. seasonal changes
   d. Heating and cooling changeover
   e. Heating or cooling capacity changes on the primary side
   f. Flow changes on the primary or secondary side
   g. Airflow changes across coil
   h. Flow across a heat exchanger
6. Adaptive control shall auto-adjust to compensate for
   a. Non-linear coils and heat exchangers
   b. Hot water and chilled water reset routines
   c. Water flow reset routines
   d. Duct Static reset routines
7. Auto-Tune PID loops are not acceptable substitutions.
8. If Adaptive Loop Control is not available, then the BAS contractor shall provide re-tuning of the control loops for coils and heat exchangers for each of the following conditions:
   a. Low heating supply water, high heating supply water
   b. Low load on steam coil, high load on steam coil

c. Chilled water coil, non dehumidification and condensing
d. Chilled water coil, low airflow, high airflow, economizer
e. Dual temperature systems tune for heating and cooling modes
f. Each of 4 seasons

G. This level of controller shall be used for the following types of systems:
1. Systems with custom sequences that meet all of the criteria below:
2. No primary pumping systems
3. Secondary Pumping systems that are remote from Central Plants
4. Air handlers up to 15,000 cfm
5. Systems up to 20 input/output points
6. Room control sequences that cannot be achieved with an application specific controller
7. BAS Network or Architecture or Sequences do not require the system to be on an IP network
8. No systems that require integration to meters, VFDs or other smart equipment
9. Integration to smart thermostats is allowed

H. Input/Outputs
1. Inputs shall be 16-bit minimum digital resolution
2. Outputs shall be 10-bit minimum digital resolution
3. The following I/O port types shall be available on the controller
a. Universal Input (software configurable):
1) Digital Input choices:
a) Pulse Accumulator
b) Contact Closure Sensing
c) Dry Contact/Potential Free inputs only
d) Digital Input (10 ms settling time)
e) Counter inputs up to 20 Hz, minimum pulse duration 20 ms (open or closed)
2) Analog Input Choices:
a) 0-10 Vdc
b) 4-20 mA
c) 1K Ni RTD @ 32°F (Siemens, JCI, DIN Ni 1K)
d) 1K Pt RTD (375 or 385 alpha) @ 32°F
e) 10K NTC Type 2 or Type 3 Thermistor
f) 100K NTC Type 2 Thermistor
b. Universal Input or Output (software configurable):
1) All of the above input types
2) Analog Output Types:
a) 0 to 10 Vdc @ 1 mA max
c. Super Universal Input or Output (software configurable):
1) All of the above input types
2) All of the above output types
3) Super digital output type:
a) 0 to 24 Vdc, 22 mA max. (for controlling pilot relay)
4) Super Analog Output Choices:

a) 0 to 20 mA @ 650 Ω max.

4. Provide software configurable I/O ports such that a programmer make a port either an input or an output

I. Each System Level Control Panel shall, at a minimum, be provided with:
1. Appropriate NEMA rated metal enclosure.
2. A 32-bit,multi-tasking, real-time 100 MHz digital control microprocessor with plug-in, enclosed processors.
3. Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
4. Real time clock and battery
5. Data collection/ Data Trend module sized for 10,000 data samples.
6. Power supplies as required for all associated modules, sensors, actuators, etc.
7. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
8. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
9. Each control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
10. Graduated intensity LEDs or analog indication of value for each analog output.

J. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for the operating system software and firmware.
1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Brownout protection and power recovery circuitry protect the controller board from power fluctuations.
3. Battery backup shall be provided to support the real-time clock for 10 years
4. The program and database information stored SDRAM memory shall be battery backed for a minimum of 30 days and up to 60 days. This eliminates the need for time consuming program and database re-entry in the event of an extended power failure.

K. Database Restore: Each AAC controller shall automatically save the latest programmed database. The controller shall be able to automatically restore a lost or corrupt database without involvement from the operator.

L. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

M. Each Control Panel shall support firmware upgrades without the need to replace hardware.

N. System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Control panels shall allow temporary use of portable operator interface devices without interrupting the normal communications.

O. Immunity to noise.
   1. 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).
   2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
      a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
      b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
      c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
      d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
   3. Isolation shall be provided at all Advanced Application Controller's AC input terminals to suppress induced voltage transients consistent with:
      a. IEEE Standard 587 1980
      b. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

P. Agency Compliance
   1. UL UL916 PAZX (all models)
   2. UL916 PAZX7 (all models)
   3. FCC Compliance CFR47 Part 15, Subpart B, Class B

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be "future" on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2.8 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

B. Controllers in areas where moisture is a concern shall be mounted in NEMA 12 enclosures.

C. Controllers installed outdoors shall be mounted in NEMA 4X enclosures. Provide heaters where freezing temperatures are normally experienced.

D. Mount on walls at an approved location or provide a free standing rack.

E. Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

F. Provide power supplies for control voltage power.

G. Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

H. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

I. All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

J. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.

K. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

L. Provide a pocket to hold documentation.

2.9 UNINTERRUPTIBLE POWER SUPPLY

A. Provide an UPS for each of the following:
   1. Supervisory Field Panels

B. Each UPS shall power the device for a minimum of 30 minutes, in the case of power interruption.

C. The UPS shall be DIN rail mounted within the associated control panel and consist of a battery power source, charger, AC output inverter system and automatic load transfer circuits for a full automatic operation. The UPS shall be an on-line type. When normal AC power returns, the UPS shall transfer the load to the rectifier output. At this time, the charger shall turn on to its 'high' charge rate until the batteries are charged approximately 80% of their rated capacity and then automatically shall switch to its maintenance 'sensing' position to keep the batteries in their best full-charge condition. Battery recharge time shall not be more than 3 hours.

D. Each UPS shall be provided, as a minimum, with pilot lights for the following conditions: "Incoming AC Power is Available", "UPS Ready Mode" and "UPS in Standby Mode". The UPS shall have the capability to hot-swap batteries without interrupting the supply of power to its users.

E. The batteries shall be of the totally enclosed nickel-cadmium type or equal. Batteries that can leak gas shall not be acceptable. There shall not be any damages should the emergency outage of line power exceed the maximum operation time of the UPS. Automatic shutdown shall occur when the UPS' maximum duty cycle is exceeded.

F. Provide APC, Liebert, or pre-approved equal.

2.10 SENSORS

A. General
1. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.
2. If a special tool is required to mount a device, provide that tool.

B. Terminal Unit Space Thermostats
1. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
a. Plain Space Temperature Sensors – Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
b. The sensing element for the space temperature sensor shall be thermistor type providing the following.
1) Element Accuracy: + /- 1.0°F
2) Operating Range: 55 to 95°F
3) Set Point Adjustment Range: 55 to 95°F
4) Calibration Adjustments: None required
5) Installation: Up to 100 ft. from controller
6) Auxiliary Communications Port: as required
7) Local LCD Temperature Display: as required
8) Setpoint Adjustment Dial as required
9) Occupancy Override Switch as required
c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.
2. Digital Display temperature sensor specifications – Wired:
a. As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
b. The sensing element for the space temperature sensor must be IC-based and provide the following.
1) Digitally communicating with the Application Specific Controller.
2) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
3) IC Element Accuracy: +/- 0.9°F
4) Operating Range: 55 to 95°F
5) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
6) Display of temperature setpoint with numerical temperature values

7) Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
8) Calibration: Single point, field adjustable at the space sensor to +/- 5°F
9) Installation: Up to 100 ft. from controller
10) Auxiliary Communications Port: included
11) Local OLED Temperature Display: included
12) Display of Temperature to one decimal place
13) Temperature Setpoint Adjustment included
14) Occupancy Override Function included

c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

3. Provide the following options as they are called for in the sequences or on the drawings:
   a. Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.
   b. Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.
   c. Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

C. Temperature Sensors
   1. All temperature sensors shall meet the following specifications:
      a. Accuracy: Plus or minus 0.2 percent at calibration point.
      b. Wire: Twisted, shielded-pair cable.
      c. Vibration and corrosion resistant
   2. Space temperature sensors shall meet the following specifications:
      a. 10k ohm type 2 thermistors
   3. Insertion Elements in Ducts shall meet the following specifications:
      a. Single point 10k ohm thermistor

b. Use where not affected by temperature stratification
c. The sensor shall reach more that 1/3 the distance from the duct wall
d. Junction box for wire splices

4. Averaging Elements in Ducts shall meet the following specifications:
   a. 72 inches (183 cm) long
   b. Flexible
   c. Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
   d. Junction box for wire splices
5. Insertion Elements for Liquids shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter
   b. Threaded mounting with matching well
   c. Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4" diameter
   d. Brass well with insertion length of 6 inches for pipes up to 10" diameter
   e. Junction box for wire splices
6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
   a. Watertight enclosure, shielded from direct sunlight
   b. Circulation fan
   c. Watertight conduit fitting

D. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:
   1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
   2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
   3. Space Sensors with LCD display:
      a. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off
      b. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint

E. Humidity Sensors shall meet the following specifications:
   1. Bulk polymer sensor element
   2. Accuracy: 2 percent full range with linear output
   3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
   4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity

F. Air Static Pressure Transmitter shall meet the following specifications:
   1. Non-directional sensor with suitable range for expected input, and temperature compensated.
   2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   3. Output: 4 to 20 mA.
   4. Building Static-Pressure Range: 0 to 0.25 inches wg.

5. Duct Static-Pressure Range: 0 to 5 inches wg.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

H. Equipment operation sensors as follows:
1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

I. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel and 0 to 10 V dc, feedback signal.

J. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vapor proof type.

K. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.

L. Leak detectors: Provide spot leak detectors that can be secured to the floor or secured to a drain pan. The detection shall used a microchip controlled energized probes. The detector shall operate on 24Vor less. Provide a way to adjust the height of the leak probes. The SPDT contacts shall be inside a watertight enclosure.

2.11 ELECTRO-MECHANICAL THERMOSTATS

A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:
1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.
1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

2.12 AUTOMATIC CONTROL VALVES

A. Manufacturers: All control valves shall be supplied from a single manufacturer. Provide valves manufactured by one of the following:
   1. Siemens
   2. Belimo
   3. Schneider Electric
   4. Honeywell
   5. Johnson Controls

B. General:
   1. All automatic control valves shall be fully proportioning, unless specified otherwise. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of control air failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements. The valves shall be capable of operating in sequence with other valves and/or dampers when required by the sequence of operation. All control valves shall be sized by the control vendor and shall be guaranteed to accommodate the flow rates as scheduled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Control valve operators shall be sized to close against a differential pressure equal to the design pump heads plus 10 percent.
   2. Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.
   3. Unless otherwise specified, control valves 2 inches and smaller shall have cast iron or bronze bodies with screwed NPT connections.
   4. Valves between 2-1/2 inch and 4 inch shall have cast iron bodies with flanged connections.
   5. All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating characteristics and accessories as described in herein. Coordinate with electrical contractor for power availability and point of connection.
   6. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless noted otherwise in these documents.
   7. All automatic control valves shall be installed by the mechanical trade.
   8. The controls contractor shall provide wiring as follows:
      a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.

b. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.
c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.
d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

C. Characterized Ball Valves
1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
2. Body pressure rating and connection type construction shall conform to fitting and valve schedules.
a. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
3. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
4. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
5. All automatic control valves shall be installed by the mechanical trade.
6. The controls contractor shall provide wiring as follows:
a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
d. All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

D. Threaded Valves, line size ½" to 2"
1. Controlled Media Specific Items
a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 230°F (110°C).
b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 230°F (110°C).
2. General Construction Materials/Applicable Standards

a. Control valve bodies shall be constructed of forged brass according to ASTM B283 (C37700, CuZn39Pb2 or equivalent), and shall meet requirements of ANSI 250 and 600WOG pressure classes.
b. Inlets and outlets shall be clearly marked on the valve bodies.
c. Valve ball shall consist of nickel-plated brass, chrome-plated brass or stainless steel.
d. End connections shall be NPT internally threaded according to ANSI B1.20.1.
e. The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
f. The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A single glass filled PTFE V port insert shall provide both the ball seal and shall establish the flow coefficient of the valve. The V port insert shall be retained by the valve body itself, not requiring additional retaining components. Flow coefficient adapters requiring a retainer clip, or installed after final assembly of the valve or as inserts in the ball shall not be allowed.
g. 2-way valves and the A-AB path on 3-way valves shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure. Bypass path (B-AB) on 3-way valves shall meet the requirements of ANSI Class III (0.1% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2.
h. Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.
i. Valve stem shall be made of brass or stainless steel.
j. Valve shall have the ability to be manually operated in the event of a power failure.

E. Actuators - Electric
1. The valves shall be provided with an actuator by the same manufacturer, factory installed.
2. All actuators shall have visual position indication.
3. No external programming device shall be required.
4. Actuator shall be electric motor driving, microprocessor signal controlled.
5. Modulating valves shall be positive positioning, responding to a 0-10VDC, 2-10VDC or 4-20mA signal. Floating modulating signals are acceptable for modulation on terminal units and radiation units. There shall be a visual valve position indicator.
6. Power: All actuators shall be 24VAC power and less than 100VA draw. Power shall be via Class 2 wiring. Actuators requiring more than 100VA shall have a dedicated conduit for power wiring, not mixed with the signal wiring.
7. Fail Safe: Valves actuators shall position the valve in a fail-safe position when the power supply is disrupted or the signal goes to 0. Fail-safe according to the following guidelines unless otherwise stated in the sequence of operations
   a. Power fail safe shall be via spring loaded mechanical means
   b. Any AHU hot water exposed to ventilation air shall fail open
   c. AHU Chilled water coils exposed to ventilation air in possible freezing conditions shall be fail open
   d. AHU Chilled water coils that are drained in winter months or are in climate zones without freezing conditions shall be fail-in-place
   e. Terminal unit valves shall fail-in-place

8. Fail in Safe valves on primary equipment such as chilled water systems, hot water systems and condenser water systems shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch.
9. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
10. Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10%, and still be rated for a Class IV leakage.
11. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
12. All automatic control valves installed in locations exposed to the elements shall be provided with weather resistant housings and heaters for climates that reach below freezing.
13. Actuators shall be UL and CSA listed.

F. Hot Water / Condenser Water / Control Valves
1. Single-seated.
2. Fully proportioning with modulating plug or V-port inner valves.
3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.
4. Stainless steel stems and trim.
5. Spring loaded Teflon packing
6. Quiet in operation.
7. Fail-safe in either normally open or normally closed position in the event of power failure.
8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

G. Differential Pressure Control Valves :
1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each closed loop water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

H. Butterfly Valves
1. All valve body connections shall be full lugged type flange connections. Wafer valves shall not be used.
2. Valves specified herein shall apply to cold water, glycol solutions and hot water up to 200F. This valve spec shall not apply to superheated water or steam systems.
3. Applications
   a. Butterfly valves shall be used for 2 position isolation.
   b. Butterfly valves shall not be used for modulation control of closed water systems, for coils, or for heat exchanger control.

c. Butterfly valves can be used for temperature control bypass on open cooling towers.
d. Butterfly valves can be used for temperature control of water injection into secondary water systems.
e. For valves that switchover between heating and cooling supply, see requirements for actuator speed under actuator specification.

4. Butterfly valves shall have body ratings in accordance with the piping specifications.
   a. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
   b. Valves that are in high static locations or where flanges are ANSI300 per the piping design shall be high performance, ANSI 300 as required by pipe specifications.
   c. Valves that are in locations where ANSI150 flanges are allowed shall be ANSI 150 valves.
   d. Undercut discs shall only be used on systems where the maximum pump total head pressure is below 50psi. Otherwise, the valve seats shall be bubble tight at a pressure higher than the maximum pump total head pressure. Maximum total pump head shall be taken from the pump curve at full speed and 0 flow.
   e. Bubble tight rating shall apply when the system is under operation and at full pressure. Bubble tight rating shall also apply when the system is not operating and under low or no pressure. Valves that require system pressure to remain bubble tight are not acceptable.
   f. Disc edge and hub on metal discs shall be spherically machined and hand polished for minimum torque and maximum sealing capability.
   g. The seat shall totally encapsulate the body isolating it from the line media and no flange gaskets shall be required.
5. Materials for ANSI 125 Bubble tight Resilient Seat Valves 2” to 12”
   a. Materials that vary from what is specified herein shall be evaluated by the Engineer.
   b. Stem 416 stainless steel
   c. Body Cast iron
   d. Packing NBR
   e. Stem Bearing Bronze
   f. Disc 304 Stainless steel
   g. Seat EPDM
6. Materials for ANSI 125 Undercut Resilient Seat Valve 4” to 20” and Bubble tight valves 14” to 20”
   a. Materials that vary from what is specified herein shall be evaluated by the Engineer.
   b. Stem 316 stainless steel or 18-8 stainless steel
   c. Body Cast iron
   d. Packing NBR
   e. Stem Bearing Sintered Metal
   f. Disc Aluminum bronze
   g. Seat EPDM
7. Materials for ANSI 300 High Performance Valves 2” to 12”

a. Materials that vary from what is specified herein shall be evaluated by the Engineer.
b. Stem 17-4 PH stainless steel
c. Body Carbon steel or stainless steel
d. Packing PTFE or Graphite
e. Stem Bearing 316 stainless steel, PTFE Bronze, or PTFE Bronze
f. Disc 316 Stainless steel or Monel (corrosive media)
g. Seat RTFE or Monel (corrosive media)

I. Butterfly Valve Actuators - Electric
1. Provide 120V or 24V powered actuators. Actuators shall be UL and CSA listed.
2. Actuator shall be fully modulating, floating, or two position, and/or spring return as indicated in the control sequences.
3. Where called for in the sequences of operations, provide a fail to a position actuators.
   a. Power Fail
      1) Valves up to 4” provide spring return power fail actuators
      2) Valves 5” to 20” provide battery or capacitor driven fail-to-position option
   b. System fail bias position with power
      1) For valves up to 4” the control signal shall determine the fail bias position
      2) For valves above 4”, the control signal shall determine the fail bias position. If the control signal is lost, the actuator shall have a signal fail bias position.
4. Modulating valves shall be positive positioning, responding to a 0-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
5. For all modulating valves provide a 0-100% position feedback signal.
6. For all 2 position valves provide a 0-100% position feedback or open and closed status end switches.
7. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
8. Valve rotation speed:
   a. In applications where the speed of the valve rotation matters, the controls contractor shall provide a means to adjust the valve rotation speed during setup and commissioning.
   b. Applications where adjustable valve rotation is required are:
      1) Switchover valves for 2- pipe heating and cooling systems
      2) Chiller condenser water isolation valves
      3) As called for in the sequences of operations
   c. Where needed, the valve rotation speed shall be adjustable in the controller program or set at the actuator electronic board. If the speed is adjustable at the controller, then the valve signal shall be a modulating signal and not a drive open/drive closed signal.
9. Provide waterproof enclosure and crankcase heater for actuator and accessories mounted outside.
10. The controls contractor shall provide wiring as follows:

a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
d. All wiring shall comply with local code requirements.
e. Total valve power draw on a circuit shall not exceed 75% of the total rated circuit at the power source. For example on a 20A circuit, valves shall not exceed 15A draw.
f. Total valve low voltage power on a circuit shall not exceed 75% of the transformer VA it is connected to. For example on a 100VA transformer, valves shall not exceed 75VA draw.
g. Segregate non-class 2 and class 2 low voltage wiring in separate conduits. Class 2 wiring shall not exceed 100VA draw. Connections to transformers with greater than 100VA draw shall be run in separate conduits from low voltage control signal wiring.

11. Provide high performance or industrial actuators on all butterfly valves. Commercial grade, direct-mount rotary style (or direct mount damper style) actuators shall only be allowed if approved by the Engineer or allowed in these specifications and meets the torque performance.
12. High performance or industrial actuators shall have the following features:
    a. Wiring terminals in a separate compartment from the valve electronics
    b. NEMA 4 enclosures. (Provide NEMA 4x or 6 in locations that require those specifications.)
    c. Adjustable torque settings at the actuator.
    d. Manual override always engaged – no clutching necessary.
    e. Anti-rust and anti-corrosive cover with anodized epoxy coating.
    f. Visual mechanical position indicator.
    g. Direct mount on valve stem – no linkages
    h. Permanently lubricated self-locking gear train eliminating the need for motor brakes.
    i. Mechanical travel stops to prevent over turning during automatic or manual wheel operation.
    j. Over temperature motor protection.
    k. Speed control on open and close rotations.
    l. Operating temperature range: -40F to 140F

J. Steam Valves:
1. Steam control valves shall be of linear flow characteristics for modulating service.
2. Sizing Criteria:
    a. 15 psig or less; pressure drop 80% of inlet psig.
    b. 16 to 50 psig; pressure drop 50% of inlet psig.
    c. Over 50 psig; pressure drop as scheduled on plans.
    d. Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:

1) Heating coils in air handlers: normally open.
2) Steam to hot water heat exchanger: normally closed.
3) Other applications: as required by sequences of operation.

2.13 PRESSURE INDEPENDENT CONTROL VALVES (PICV)

A. Manufacturers: All PICV valves shall be supplied from a single manufacturer. Provide valves manufactured by one of the following:
   1. Siemens
   2. Belimo
   3. Schneider Electric
   4. Honeywell
   5. Johnson Controls

B. General
   1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
      a. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
   2. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
   3. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
   4. All automatic control valves shall be installed by the mechanical trade.
   5. The controls contractor shall provide wiring as follows:
      a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
      b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
      c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
      d. All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

C. Where to use PICVs
   1. Provide PICVs where called for in the specifications, sequences of operations, or on the drawings.
   2. If it is not stated elsewhere, PICV valves should be provided to meet the following guidelines:
      a. Provide in direct return, constant speed pumping systems.

b. Provide in direct return, variable flow water systems where with the system at full flow the pressure differential between the supply connection and the return connection is more than double the pressure drop of the circuit or loop at design flow (including piping, fittings, devices, control valve and coil).
c. Provide in reverse return, constant speed pumping systems where the circuits and loop pressure drops differ by more than 50%.
d. Provide in reverse return, variable speed pumping systems where the differential pressure between the systems will vary more than the pressure drop of the circuit or loop.
e. Provide in systems that have direct return headers and reverse return branch lines where with the system at full flow the pressure differential between the supply connection and the return connection is more than double the pressure drop of the branch at design flow (including piping, fittings, devices, control valve and coil).

D. Piping for circuits with PICVs
1. Systems installed with PICVs shall not require balancing valves.
2. Calibrated balancing valves shall not be required in branches or loops where PICV are installed.
3. Automatic flow control valves are strictly prohibited in branches or loops where PICVs are installed.
4. Circuit setters may be required for coils with multiple sections. Follow the piping details.
5. Install pressure ports on either side of the coil for the balancer to test the flow across the coil at different system flows.

E. Sizing Criteria (Pressure Independent):
1. Two-way modulating service:
a. Determine the design GPM of the actual coil that is selected be used (may be different than the coil and GPM on the design coil schedule).
b. Select the PICV valve with a GPM rating higher than the GPM required.
c. If more than one valve fits the GPM rating, then pick the valve that matches or is closest to the line size of the circuit piping.
d. If the maximum GPM of the valve exceeds the design GPM required, then adjust the Flow Limiter setting on the valve to the GPM required.
e. Traditional flow coefficient and pressure drop sizing is not applicable to PICV valves.

F. Flanged Valves, line size 2 ½" and larger
1. Controlled Media Specific Items
a. The control valve shall be suitable for chilled water to a minimum of 34°F (1°C) and hot water to a maximum temperature of 248°F (120°C).
b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 34°F (1°C) and hot glycol/water solutions to a maximum temperature of 248°F (120°C).
2. General Construction Materials/Applicable
a. Control valve bodies shall be constructed of cast iron and shall meet requirements of ANSI 125 or ANSI 250 pressure classes.
b. Inlets and outlets shall be clearly marked on the valve bodies.

c. Valves shall be constructed with a single chamber and multiple seats to provide flow limiting, pressure compensation and flow control.
d. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.
e. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.
f. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.
    1) A table shall be attached to each valve indicating GPM corresponding to each setting on the dial.
    2) No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into the valve body.
    3) The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.
    4) The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.
g. At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be ±10% or less.
h. Pressure ports shall be standard in the body of the valve for all flanged valves. Pressure ports shall provide a means for a balancer to test the differential pressure across the valve control port to ensure the PICV is operating within the pressure independent range.
i. Valves 2-1/2 inch and larger shall be provided with ANSI 125 or ANSI 250 flanged connections.
j. Valves 2-1/2 inch and larger line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off.
k. The differential pressure range for effective pressure independent operation shall be 3.6 – 90 psi or 8 – 90 psi for 2-½ and 3 inch flanged valves and 5 – 90 psi or ≤ 10 – 90 psi for 4 to 6 inch flanged valves, depending on the maximum gpm flow range of the valve.
l. Valve materials shall meet or exceed the following:
    1) Valve body: Cast iron
    2) Stem, spring: Stainless steel
    3) Seat: Stainless steel
    4) Plug: Brass and EPDM
    5) Seals: EPDM (peroxide cured)

G. Threaded Valves, line size ½" to 2"
    1. Controlled Media Specific Items

a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C).
b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C).

2. General Construction Materials/Applicable Standards
   a. Control valve bodies shall be constructed of forged DZR brass or ductile iron and shall meet requirements of ANSI 250 pressure class.
   b. Inlets and outlets shall be clearly marked on the valve bodies.
   c. Valves shall be constructed with a single chamber and multiple seats to provide flow limiting, pressure compensation and flow control.
   d. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.
   e. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.
   f. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.
      1) The dial shall show settings in GPM.
      2) No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into the valve body.
      3) The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.
      4) The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.
   g. At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be +/- 5% from 5 to 58psi and ≤-10% from Δp min. to 5 psi.
   h. Pressure ports shall be an optional accessory that can be added to threaded valves. Pressure ports shall provide a means for a balancer to test the differential pressure across the valve control port to ensure the PICV is operating within the pressure independent range.
   i. Valves 2 inch and smaller shall be provided female NPT piping connections.
   j. Close-off and leakage
      1) Normally open valves 1-1/4 inch and smaller line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 200 psi close off.
      2) Normally closed valves 1-1/4 inch and smaller line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 45 psi close off.

3) Valves 1-1/2 and 2 inch line sizes shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off.Differential pressure ranges:
4) The start-up differential pressure of the automatic differential pressure regulator shall be between 2.3 and 5 psi, depending on valve size and flow rate for ½ to 2 inch valves.
5) The maximum operating differential pressure of the automatic differential pressure regulator shall be 58 psi for ½ to 2 inch valves.
6) In no instance shall the minimum effective pressure differential for effective pressure independent operation exceed 5 psi for valves less than or equal to 2 inch line size.

k. Valve materials shall meet or exceed the following:
1) Valve body: DZR brass or ductile iron
2) Stem, spring: Stainless steel
3) Seat: brass
4) Plug: Brass and EPDM
5) Seals: EPDM (peroxide cured)

2.14 ELECTRONIC ACTUATOR SPECIFICATION

A. ELECTRONIC VALVE ACTUATORS

1. Actuator shall be fully modulating, floating (tri-state), two position, and/or spring return as indicated in the control sequences. Specified fail safe actuators shall require mechanical spring return.
2. Modulating valves shall be positive positioning, responding to a 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
3. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
4. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
5. Actuators shall be UL listed.

B. ELECTRONIC DAMPER ACTUATORS

1. Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.
2. Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.
3. For power-failure/safety applications, a mechanical, spring return mechanism shall be used.

4. Actuators with spring return mechanisms shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
5. Proportional actuators shall accept a 2-10VDC, 4-20mA signal, or be of the 2 point floating type and provide a 2-10VDC actuator position feedback signal.
6. All actuators shall have an external manual gear release (clutch) or manual crank to aid in installation and for allowing manual positioning when the actuator is not powered.
7. All actuators shall have an external direction of rotation switch to aid in installation and to allow proper control response.
8. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box.
9. Actuators shall be listed under Underwriters Laboratories Standard 873 and Canadian Standards Association. They must be manufactured under ISO 9001.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or 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.

3.2 INSTALLATION

A. Provide all relays, switches, sources of emergency and UPS battery back-up electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.

B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

D. Install equipment level and plumb.

E. Install control valves horizontally with the power unit up.

F. Unless otherwise noted, install wall mounted thermostats and humidistat 60” above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.

G. Install averaging elements in ducts and plenums in horizontal crossing or zigzag pattern.

H. Install outdoor sensors in perforated tube and sunshield.

I. Install damper motors on outside of duct in protected areas, not in locations exposed to outdoor temperatures.

J. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

K. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.

L. Furnish automatic dampers to mechanical contractor for installation.

3.3 GRAPHIC DISPLAY GENERATION

A. All software shall be capable of providing color graphics. All software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

B. Provide a main default screen showing the basic layout of the building. Each color graphic screen shall have transfer links to allow the building operator to transfer between system associated screens (both forward and backward), as well as a transfer link back to the main default screen.

C. Basic CAD floor plans with layers for walls, windows, low pressure ductwork only, supply diffusers and room numbers shall be provided for all CV, VAV, and FPVAV terminal units. Floor plans shall show the location of each space temperature sensor with a dashed line to the associated terminal unit. Display in real time the difference between the space temperature and the current setpoint.
   1. Display the
      a. cooling %,
      b. heating % (if applicable)
      c. current CFM of each terminal unit.
   2. Provide a transfer link for each terminal unit to allow the operator to access the flow graphic for each individual terminal unit. Use a different color to shade the background area for each part of a floor plan graphic served by a different air handling unit.

D. All control set points shall be easily adjustable from the system’s color graphic screen by operators with the proper access level. Each controlled point on the BAS operator workstation color graphic screens shall have the set point indicated along with the actual controlled variable

reading (preferred set point on top and actual reading on bottom). All points shall indicate the associated engineering unit. All analog outputs points shall indicate engineering units such as "%-open" or "%-closed" as required by the application. All normally-closed or normally-open points shall indicate the normal position (such as "N.C." or "N.O." next to the controlled device).

E. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS. Provide scaled floor plans indicating equipment location, service, and system data as required.

F. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

G. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

H. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

I. The windowing environment of the operator interface shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
   1. Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   2. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

J. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers.

K. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

L. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

M. Provide an additional dynamic, graphic display pages as required by the operating staff to further assist in daily system operations.

N. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

O. Each graphic shall have a “BACK” button and a “HOME” or “MAIN” button located in the same location on all graphics.

P. The operator shall be able to clearly distinguish the difference between the following types of points on a graphic either by color, shape, icon or text label:
   1. Real-time sensor reading
   2. Setpoint
   3. Manually set vs. program set Setpoint
   4. Real-time output reading
   5. Manually Overridden or commanded output vs program set output
   6. Status feedback from a piece of equipment vs the output command
   7.

Q. Make appear links to additional information associated with the system on the graphic, such as:
   1. Controls as-built schematics and wiring diagrams
   2. As-built Sequence of Operation
   3. Mechanical drawings
   4. Electrical drawings

R. Integration graphics shall be representative of personnel standing in front of equipment. The graphics for equipment specified in the Building Systems Integration paragraph shall be representative of the manufacturers’ local display panel and each shall be completely operable from the computer workstation.

3.4 ELECTRICAL WIRING SCOPE

A. This contractor shall be responsible for power that is not shown on the electrical drawings, to controls furnished by this contractor. If power circuits are shown on the electrical drawings, this contractor shall continue the power run to the control device. If power circuits are not shown, this contractor shall coordinate with the electrical contractor to provide breakers at distribution panels for power to controls. This contractor is then responsible for power from the distribution panel.
   1. Coordinate panel locations. If enclosures for panels are shown on the electrical drawings, furnish the enclosures according to the electrician’s installation schedule.

B. This contractor shall not be responsible for power to control panels and control devices that are furnished by others, unless it is part of the control interlock wiring.

C. Refer to Coordination section for what devices this contractor is responsible to mount and which are turned over to others to mount.

D. This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

E. Interlock wiring shall be run in separate conduits from BAS associated wiring.

F. Provide network wiring for equipment that is called to be integrated to the BAS.

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

B. Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

C. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

D. Install building wire and cable according to Division 26 Section "Conductors and Cables."

E. Installation shall meet the following requirements:
   1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway or conduit.
   3. Install concealed cable using plenum rated cable.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. All wiring in lab areas shall be in conduit.
   8. All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.

F. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

G. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

H. Install conduit adjacent to machine to allow service and maintenance.

I. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

J. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

K. Ground equipment.

3.6 COMMUNICATION WIRING

A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

B. Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

E. Cable bundling:
   1. RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.
   2. RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.
   3. RS485 cabling run between floors shall be in a communication only conduit.
   4. RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.
   5. Ethernet cabling shall be in a communication only conduit.
   6. Ethernet and RS485 can be run together.
   7. Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

F. RS485 Cabling
   1. RS485 cabling shall be used for BACnet MS/TP networks.
   2. RS485 shall use low capacitance, 20-24 gauge, twisted shielded pair.
   3. The shields shall be tied together at each device.
   4. The shield shall be grounded at one end only and capped at the other end.
   5. Provide end of line (EOL) termination devices at each end of the RS485 network or subnetwork run, to match the impedance of the cable, 100 to 120ohm.

G. Ethernet Cabling
   1. Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.
   2. CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.
   3. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
   4. When the BAS Ethernet connects to an Owner's network switch, document the port number on the BAS As-builts.

H. Fiber-Optic Cabling
   1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.

2. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.
3. All terminations shall to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

I. 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 the manufacturer's instructions.

J. All runs of communication wiring shall be unspliced length when that length is commercially available.

K. All communication wiring shall be labeled to indicate origination and destination data.

L. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.7 IDENTIFICATION

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows: C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows: C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

C. Control Equipment and Device labeling:
1. Labels and tags shall match the unique identifiers shown on the as-built drawings.
2. All Enclosures shall be labeled to match the as-built drawing by either control panel name or the names of the DDC controllers inside.
3. All sensors and actuators not in occupied areas shall be tagged.
4. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
5. Duct static pressure taps shall be tagged at the location of the pressure tap.
6. Each device inside enclosures shall be tagged.
7. Terminal equipment need only have a tag for the unique terminal number, not for each device. Match the unique number on:
   a. First, the design drawings, or
   b. Second, the control as-builts, or

c. Third, the DDC addressing scheme

8. Tags on the terminal units shall be displayed on the Operator Workstation Graphics.

D. Tags shall be mechanically printed on permanent adhesive backed labeling strips, 12 point height minimum.

E. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

F. Identification of Wires
1. Tag each wire with a common identifier on each end of the wire, such as in the control panel and at the device termination.
2. Tag each network wire with a common identifier on each end.
3. Tag each 120V power source with the panel and breaker number it is fed by.

G. Identification of Conduits:
1. Identify the low voltage conduit runs as BAS conduit, power feeds not included.
2. Identify each electric box, junction box, utility box and wiring tray with a blue paint mark or blue permanent adhesive sticker.
3. For conduit runs that run more than 8 ft between junction boxes in 1 room, place a blue identifier at least every 8 feet.
4. Place a blue identifier on each side of where a conduit passed through a wall or other inaccessible path.
5. Identify all BAS communication conduits the same as above.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
3. Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.
1. Start, test, and adjust control systems.
2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.9 SYSTEM CHECKOUT AND STARTUP

A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:
   1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
   2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
   3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.
   4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
   5. Command each relay to open and close to verify its operation.
   6. Command each 2-position damper actuator to open and close to verify operation.
   7. Command each 2-position valve to open and close to verify operation.
   8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
   9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.
   10. Test each safety device with a real life simulation, for instance check low temperature detectors with ice water, water detectors with water, etc.

C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

D. Verify that each DDC controller communicates on its respective network correctly.

E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:
   1. Start systems from DDC.
   2. Verify that each setpoint can be met by the system.
   3. Change setpoints and verify system response.
   4. Change sensor readings to verify system response.
   5. Test safety shutdowns.
   6. Verify time delays.
   7. Verify mode changes.
   8. Adjust filter switches and current switches for proper reactions.
   9. Adjust proportional bands and integration times to stabilize control loops.

F. Perform all program changes and debugging of the system for a fully operational system.

G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.10 SYSTEM COMMISSIONING, DEMONSTRATION AND TURNOVER

A. The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

B. After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

C. The BAS contractor shall fix punch list items within 30 days of acceptance.

D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.11 TRAINING

A. During System commissioning and at such time as acceptable performance of the Building Automation System hardware and software has been established, the BAS contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction during normal working hours shall be performed by a competent building automation contractor representative familiar with the Building Automation System's software, hardware and accessories.

B. At a time mutually agreed upon, during System commissioning as stated above, the BAS contractor shall give 40 hours of onsite training on the operation of all BAS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:
   1. Explanation of drawings and operator’s maintenance manuals.
   2. Walk-through of the job to locate all control components.
   3. Operator workstation and peripherals.
   4. DDC Controller and ASC operation/sequence.
   5. Operator control functions including scheduling, alarming, and trending.
   6. Explanation of adjustment, calibration and replacement procedures.

C. Additional 8-hours of training shall be given after the 30 day shakedown period.

D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.Points List

END OF SECTION 230923

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Chilled-water piping.
   2. Makeup-water piping.
   3. Air-vent piping.
   4. Safety-valve-inlet and -outlet piping.

1.2 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
   1. Chilled-Water Piping: 150 psig at 200 deg F.
   2. Makeup-Water Piping: 80 psig at 150 deg F.
   3. Condensate-Drain Piping: 150 deg F.
   4. Air-Vent Piping: 200 deg F.
   5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.3 SUBMITTALS

A. Product Data: For each type of the following:
   1. Plastic pipe and fittings with solvent cement.
   2. RTRP and RTRF with adhesive.
   3. Pressure-seal fittings.
   4. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   5. Air control devices.
   6. Chemical treatment.
   7. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding certificates.

D. Qualification Data: For Installer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

G. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. 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 01.

1.5 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Coordinate flange class in first paragraph below with products in other parts of this Section and in related Sections to match face size and bolt patterns.

F. 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 Part 3 "Piping Applications" Article.

G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

H. 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.

2.3 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 thickness or specific material is 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. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. 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.

G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Charlotte Pipe and Foundry Company.
b. IPEX Inc.
c. KBi.
2. CPVC and PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions:
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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Charlotte Pipe and Foundry Company.
b. IPEX Inc.
c. KBi.
d. NIBCO INC.
3. MSS SP-107, CPVC and PVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Capitol Manufacturing Company.
b. Central Plastics Company.

c. Hart Industries International, Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Calpico, Inc.
b. Lochinvar Corporation.
2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Perfection Corporation; a subsidiary of American Meter Company.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Company, Inc.
d. Victaulic Company of America.
2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.6 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "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; a division of ITT Industries.
c. Flow Design Inc.
d. Gerand Engineering Co.
e. Griswold Controls.
f. Taco.
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; a division of ITT Industries.
c. Flow Design Inc.
d. Gerand Engineering Co.
e. Griswold Controls.
f. Taco.
g. Tour & Andersson; available through Victaulic Company of America.
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. 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.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
4. Combination Assemblies: Include bonze 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: 300 psig.
9. Maximum Operating Temperature: 200 deg F.

2.7 AIR CONTROL DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

D. Bladder-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig.
3. Maximum Operating Temperature: Up to 300 deg F.

F. Air Purgers:
1. 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.
2. Maximum Working Pressure: 150 psig.
3. Maximum Operating Temperature: 250 deg F.

2.8 CHEMICAL TREATMENT

A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.9 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: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. 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.

C. 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.

D. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled-water and run around loop 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 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Chilled-water and run around loop piping, aboveground, NPS 2-1/2 and larger, shall be any of 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. Makeup-water piping installed aboveground shall be the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

E. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

F. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

G. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

H. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 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; and 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.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such 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 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 3/4 threaded 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 mechanically formed 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 Division 23 Section "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 strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "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 Division 23 Section "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 Division 23 Section "Escutcheons for HVAC Piping."

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

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.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 3/8 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 1/2 inch.
7. NPS 3: Maximum span, 12 feet; minimum rod size, 1/2 inch.
8. NPS 3-1/2: Maximum span, 13 feet; minimum rod size, 1/2 inch.
9. NPS 4: Maximum span, 14 feet; minimum rod size, 5/8 inch.
10. NPS 5: Maximum span, 16 feet; minimum rod size, 5/8 inch.
11. NPS 6: Maximum span, 17 feet; minimum rod size, 3/4 inch.
12. NPS 8: Maximum span, 19 feet; minimum rod size, 3/4 inch.

E. Install hangers for drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
3. NPS 1-1/4: Maximum 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, 1/2 inch.
7. NPS 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. 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.

E. 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.

F. 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.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic 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 Non-pressure Piping: Join according to ASTM D 2855.

3.6 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. Manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.7 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 bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.8 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 "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 232113

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Close-coupled, in-line centrifugal pumps.

1.2 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.3 SUBMITTALS

A. Product Data: 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: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.6 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.

1.7 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. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 BASE MOUNTED, END SUCTION PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett Series e-1510 Pumps or a comparable product by one of the following.
   1. Taco, Inc.
   2. Armstrong Pumps Inc.
   3. Aurora Pump; Division of Pentair Pump Group.
   4. Weinman; Div. of Crane Pumps & Systems.

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. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 200 deg F.

C. Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

E. Capacities and Characteristics: (See schedule on drawings.)

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 175-psig pressure rating, ductile-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of 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.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of 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. Install continuous-thread hanger rods and spring hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Division 21 Section "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment." Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment/Hangers and Supports for HVAC Piping and Equipment."

F. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.3 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

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.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow 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 triple-duty valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

I. Install electrical connections for power, controls, and devices.

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

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

3.5 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.

3.6 DEMONSTRATION

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

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

~~A. Line Test Pressure for Refrigerant R-22:~~
~~1. Suction Lines for Air-Conditioning Applications: 185 psig (1276 kPa).~~
~~2. Suction Lines for Heat-Pump Applications: 325 psig (2241 kPa).~~
~~3. Hot-Gas and Liquid Lines: 325 psig (2241 kPa).~~

~~B. Line Test Pressure for Refrigerant R-134a:~~
~~1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).~~
~~2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).~~
~~3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).~~

~~C. Line Test Pressure for Refrigerant R-407C:~~
~~1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).~~
~~2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).~~
~~3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).~~

~~D.~~A. Line Test Pressure for Refrigerant R-410A:
1. Suction Lines for Air-Conditioning Applications: 300 psig ~~(2068 kPa)~~.
2. Suction Lines for Heat-Pump Applications: 535 psig ~~(3689 kPa)~~.
3. Hot-Gas and Liquid Lines: 535 psig ~~(3689 kPa)~~.

1.4 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. Hot-gas bypass valves.~~

~~4.~~3. Filter dryers.
~~5.~~4. Strainers.
~~6.~~5. Pressure-regulating valves.

~~B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.~~

~~1. Shop Drawing Scale: [**1/4 inch equals 1 foot (1:50)**] <**Insert value**>.~~

~~Retain subparagraph below to have Contractor size and design refrigeration piping.~~

~~2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.~~

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 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."

1.8 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.

~~1.9 COORDINATION~~

~~A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."~~

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ~~[ASTM B 88, Type K or L (ASTM B 88M, Type A or B)]~~ [ASTM B 280~~0, Type ACR~~~~]~~.

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 ~~(20-mm)~~ misalignment in minimum 7-inch ~~(180-mm-)~~ long assembly.
4. Pressure Rating: Factory test at minimum 500 psig ~~(3450 kPa)~~.
5. Maximum Operating Temperature: 250 deg F ~~(121 deg C)~~.

2.2 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 ~~(3450 kPa)~~.
7. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

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 ~~(3450 kPa)~~.
8. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

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 ~~(3.4 kPa)~~.
8. Working Pressure Rating: 500 psig ~~(3450 kPa)~~.
9. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

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 ~~(3450 kPa)~~.

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 ~~(16-GRC)~~ conduit adapter, and ~~[~~24~~]~~ ~~[115]~~ ~~[208]~~-V ac coil.
6. Working Pressure Rating: 400 psig ~~(2760 kPa)~~.
7. Maximum Operating Temperature: 240 deg F ~~(116 deg C)~~.
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 ~~(2760 kPa)~~.
6. Maximum Operating Temperature: 240 deg F ~~(116 deg C)~~.

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 ~~(4.4 deg C)] <Insert temperature>~~.
6. Superheat: ~~[Adjustable] [~~Nonadjustable~~]~~.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: ~~[700 psig (4820 kPa)] [~~450 psig ~~(3100 kPa)] <Insert value>~~.

~~H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.~~
~~1. Body, Bonnet, and Seal Cap: Ductile iron or steel.~~
~~2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.~~
~~3. Packing and Gaskets: Non-asbestos.~~
~~4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.~~
~~5. Seat: Polytetrafluoroethylene.~~
~~6. Equalizer: [**Internal**] [**External**].~~
~~7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [**24**] [**115**] [**208**] V ac coil.~~
~~8. End Connections: Socket.~~
~~9. Set Pressure: <**Insert psig (kPa).**>~~
~~10. Throttling Range: Maximum 5 psig (34 kPa).~~
~~11. Working Pressure Rating: 500 psig (3450 kPa).~~
~~12. Maximum Operating Temperature: 240 deg F (116 deg C).~~

~~I.~~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 ~~(3450 kPa)~~.
5. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

~~J.~~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 ~~(3450 kPa)~~.
6. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

~~K.~~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 ~~(3450 kPa)~~.
7. Maximum Operating Temperature: 240 deg F ~~(116 deg C)~~.

~~L.~~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~~] [charcoal]~~.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4~~(DN 8)~~ connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: ~~[~~2 psig ~~(14 kPa)] <Insert value>~~.
~~8. Rated Flow: <Insert tons (kW).>~~
~~9.~~8. Working Pressure Rating: 500 psig ~~(3450 kPa)~~.
~~10.~~9. Maximum Operating Temperature: 240 deg F ~~(116 deg C)~~.

~~M.~~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~~] [.~~**~~charcoal~~]~~.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4~~(DN 8)~~ connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: ~~[~~2 psig~~(14 kPa)] <Insert value>.~~
~~8. Rated Flow: <Insert tons (kW).>~~
~~9.~~8. Working Pressure Rating: 500 psig ~~(3450 kPa)~~.
~~10.~~9. Maximum Operating Temperature: 240 deg F ~~(116 deg C)~~.

~~N.~~M. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig ~~(3450 kPa)~~.
4. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

~~O.~~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 ~~(3450 kPa)~~.
7. Maximum Operating Temperature: 275 deg F ~~(135 deg C)~~.

P.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 (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.3 REFRIGERANTS

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. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.
5. <**Insert manufacturer's name.**>

C. ASHRAE 34, R-22: Monochlorodifluoromethane.

D. ASHRAE 34, R-134a: Tetrafluoroethane.

E. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

F.C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-22

Retain one or both paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller. Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain both paragraphs to require piping larger than NPS 1-1/2 (DN 40) to be different than Type ACR, annealed temper. Delete both paragraphs if suction lines are part of a heat-pump installation.

A. Suction Lines [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [**NPS 4 (DN 100) and Smaller**] [**NPS 2 to NPS 4 (DN 50 to DN 100)**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Retain one of three paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller. Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain third paragraph and subparagraphs to require different tube type and joining methods for various pipe sizes.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

Retain one of first two subparagraphs below.

1. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [**NPS 2 to NPS 3 (DN 50 to DN 80)**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [**NPS 4 (DN 100)**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

Retain one of three paragraphs below. Retain first paragraph to require all safety-relief-valve discharge piping to be steel. Retain second paragraph to require all pipe sizes to be copper of same tube type and joining method. Retain third paragraph and subparagraphs to require different tube type and joining methods for various pipe sizes.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:

Retain one of first two subparagraphs below.

1. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [**NPS 2 to NPS 3 (DN 50 to DN 80)**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [**NPS 4 (DN 100)**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134a

Retain one or both paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller. Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain both paragraphs to require piping larger than NPS 1-1/2 (DN 40) to be different than Type ACR, annealed temper. Delete both paragraphs if suction lines are part of a heat-pump installation.

A. Suction Lines [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [**NPS 4 (DN 100) and Smaller**] [**NPS 2 to NPS 4 (DN 50 to DN 100)**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Retain one of three paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller. Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain third paragraph and subparagraphs to require different tube type and joining methods for various pipe sizes.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

Retain one of first two subparagraphs below.

1. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [**NPS 4 (DN 100)**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Retain one of three paragraphs below. Retain first paragraph to require all safety-relief-valve discharge piping to be steel. Retain second paragraph to require all pipe sizes to be copper of same tube type and joining method. Retain third paragraph and subparagraphs to require different tube type and joining methods for various pipe sizes.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:

Retain one of first two subparagraphs below.

1. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**]joints.
3. [**NPS 4 (DN 100)**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

Retain one or both paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller. Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain both paragraphs to require piping larger than NPS 1-1/2 (DN 40) to be different than Type ACR, annealed temper. Delete both paragraphs if suction lines are part of a heat-pump installation.

A. Suction Lines [**NPS 1-1/2 (DN 40) and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

B. Suction Lines [**NPS 4 (DN 100) and Smaller**] [**NPS 2 to NPS 4 (DN 50 to DN 100)**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Retain one of three paragraphs below. Retain first paragraph to require all piping to be Type ACR, annealed temper. Type ACR, annealed-temper tubing is available only in sizes NPS 1-1/2 (DN 40) and smaller; however, brazed ACR can withstand pressure of this service only up to NPS 1 (DN 25). Retain second paragraph if pipe sizes exceed NPS 1-1/2 (DN 40) and it is desirable to have all piping be of same tube type and joining method. Retain third paragraph and subparagraphs to require different tube type and joining methods for various pipe sizes.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

Retain one of first two subparagraphs below.

1. [**NPS 1 (DN 25) and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 1 (DN 25) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [**NPS 1-1/4 to NPS 2 (DN 32 to DN 50)**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

4. [**NPS 4 (DN 100)**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

Retain one of three paragraphs below. Retain first paragraph to require all safety-relief-valve discharge piping to be steel. Retain second paragraph to require all pipe sizes to be copper of same tube type and joining method. Retain third paragraph and subparagraphs to require different tube type and joining methods for various pipe sizes.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

H. Safety-Relief-Valve Discharge Piping:

Retain one of first two subparagraphs below.

1. [**NPS 1 (DN 25) and Smaller**] <**Insert pipe size range**>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 1 (DN 25) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**]joints.
3. [**NPS 1-1/4 to NPS 2 (DN 32 to DN 50)**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
4. [**NPS 4 (DN 100)**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

3.43.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines [NPS 1-1/2 (DN 40) and Smaller] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.

B. Suction Lines [NPS 3-1/2 (DN 90) and Smaller] [NPS 2 to NPS 3-1/2 (DN 50 to DN 90)] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, Type [ACR] [L (B)], drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.

C. Suction Lines [NPS 4 (DN 100) and Smaller] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, Type [ACR] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with soldered joints.

D.B. Hot-Gas and Liquid Lines[, and Suction Lines for Heat-Pump Applications]: Copper, Type [ACR] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.

E. Hot-Gas and Liquid Lines[, and Suction Lines for Heat-Pump Applications]: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.

Retain paragraph below for tubing not larger than NPS 1-1/4 (DN 32) and it is desirable to have all piping be of same tube type and joining method.

F. Hot-Gas and Liquid Lines[, and Suction Lines for Heat-Pump Applications]: Copper, Type [ACR] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

Retain paragraph below for tubing not larger than NPS 2 (DN 50) and it is desirable to have all piping be of same tube type and joining method.

G. Hot-Gas and Liquid Lines[, and Suction Lines for Heat-Pump Applications]: Copper, Type [ACR] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

H. Hot-Gas and Liquid Lines[, and Suction Lines for Heat-Pump Applications]:
1. [NPS 5/8 (DN 18) and Smaller] <Insert pipe size range>: Copper, Type [ACR] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
2. [NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller] <Insert pipe size range>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
3. [NPS 1-1/4 (DN 32) and Smaller] <Insert pipe size range>: Copper, Type [ACR] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. [NPS 1-1/2 to NPS 2 (DN 40 to DN 50)] <Insert pipe size range>: Copper, Type [ACR] [K (A)] [L (B)], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

Retain paragraph below if required pipe sizes exceed copper pipe sizes in paragraph and subparagraphs above.

I. Hot-Gas and Liquid Lines[, and Suction Lines for Heat-Pump Applications] [NPS 2 to NPS 4 (DN 50 to DN 100)] <Insert pipe size range>: Schedule 40, black-steel and wrought-steel fittings with welded joints.

J.C. Safety-Relief-Valve Discharge Piping: Copper, Type [ACR] [L (B)], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.

K. Safety-Relief-Valve Discharge Piping: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Retain paragraph below for tubing not larger than NPS 1-1/4 (DN 32) and it is desirable to have all piping be of same tube type and joining method.

L. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

Retain paragraph below for tubing not larger than NPS 2 (DN 50) and it is desirable to have all piping be of same tube type and joining method.

M. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

Retain paragraph and subparagraphs below to require different tube type and joining methods for various pipe sizes.

N. Safety-Relief-Valve Discharge Piping:
1. [**NPS 5/8 (DN 18) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L (B)**], annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. [**NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller**] <**Insert pipe size range**>: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
3. [**NPS 1-1/4 (DN 32) and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
4. [**NPS 1-1/2 to NPS 2 (DN 40 to DN 50)**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

Retain paragraph below if required pipe sizes exceed copper pipe sizes in paragraph and subparagraphs above.

O. Safety-Relief-Valve Discharge Piping [**NPS 2 to NPS 4 (DN 50 to DN 100)**] <**Insert pipe size range**>: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.53.2 VALVE AND SPECIALTY APPLICATIONS

A. Install [diaphragm packless] [packed-angle] 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] [packed-angle] 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.

~~3.6~~3.3 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.

~~5.~~

~~P.~~Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

~~Q.~~R. Identify refrigerant piping and valves according to Section 23 05 53 "Identification for HVAC Piping and Equipment."

~~R.~~S. 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."

~~S.~~T. 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."

~~T.~~U. 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."

~~3.7~~3.4 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.
~~F.~~2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

~~3.8~~3.5 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 ~~(6 m)~~ long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet ~~(6 m)~~ or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet ~~(6 m)~~ 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 ~~(DN 15)~~: Maximum span, 60 inches ~~(1500 mm)~~; minimum rod size, 1/4 inch ~~(6.4 mm)~~.
2. NPS 5/8 ~~(DN 18)~~: Maximum span, 60 inches ~~(1500 mm)~~; minimum rod size, 1/4 inch ~~(6.4 mm)~~.
3. NPS 1 ~~(DN 25)~~: Maximum span, 72 inches ~~(1800 mm)~~; minimum rod size, 1/4 inch ~~(6.4 mm)~~.
4. NPS 1-1/4 ~~(DN 32)~~: Maximum span, 96 inches ~~(2400 mm)~~; minimum rod size, 3/8 inch ~~(9.5 mm)~~.

5. NPS 1-1/2 ~~(DN 40)~~: Maximum span, 96 inches ~~(2400 mm)~~; minimum rod size, 3/8 inch ~~(9.5 mm)~~.
6. NPS 2 ~~(DN 50)~~: Maximum span, 96 inches ~~(2400 mm)~~; minimum rod size, 3/8 inch ~~(9.5 mm)~~.
7. NPS 2-1/2 ~~(DN 65)~~: Maximum span, 108 inches ~~(2700 mm)~~; minimum rod size, 3/8 inch ~~(9.5 mm)~~.
8. NPS 3 ~~(DN 80)~~: Maximum span, 10 feet ~~(3 m)~~; minimum rod size, 3/8 inch ~~(9.5 mm)~~.
9. NPS 4 ~~(DN 100)~~: Maximum span, 12 feet ~~(3.7 m)~~; minimum rod size, 1/2 inch ~~(13 mm)~~.

D. Support multifloor vertical runs at least at each floor.

~~3.9~~3.6 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.

~~3.10~~3.7 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 ~~(67 Pa)~~. 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 ~~(14 kPa)~~.
4. Charge system with a new filter-dryer core in charging line.

~~3.11~~3.8 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 232300 ~~232300~~

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following HVAC water-treatment systems:
   1. Bypass chemical-feed equipment and controls.
   2. Biocide chemical-feed equipment and controls.
   3. Chemical treatment test equipment.
   4. HVAC water-treatment chemicals.
   5. Water filtration units for HVAC makeup water.

1.3 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

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. RO: Reverse osmosis.

D. TDS: Total dissolved solids.

E. UV: Ultraviolet.

1.4 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating, 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.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TDS: 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 0 organisms/ml.
    e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

1.5 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. TDS controllers.
6. Biocide feeder timers.
7. Chemical solution tanks.
8. Injection pumps.
9. Ozone generators.
10. UV-irradiation units.
11. Chemical test equipment.
12. Chemical material safety data sheets.
13. Water softeners.
14. RO units.
15. Multimedia filters.
16. Self-cleaning strainers.
17. Bag- or cartridge-type filters.
18. Centrifugal separators.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: Power and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

E. Other Informational Submittals:
1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

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.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for cooling, chilled-water piping, heating, hot-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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. Ampion Corp.
2. Anderson Chemical Co, Inc.
3. Aqua-Chem, Inc.; Cleaver-Brooks Div.
4. Barclay Chemical Co.; Water Management, Inc.
5. Boland Trane Services
6. GE Betz.
7. GE Osmonics.
8. H-O-H Chemicals, Inc.
9. Metro Group. Inc. (The); Metropolitan Refining Div.
10. ONDEO Nalco Company.
11. Watcon, Inc.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
1. Capacity: 5 gal..
2. Minimum Working Pressure: 125 psig.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:
1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 100 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded.
7. Control: Low-voltage signal capable of transmitting 1000 feet.

B. Inhibitor Injection Timers:
1. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two

water meter inputs.

C. pH Controller:
1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low pH alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

D. TDS Controller:
1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High or low conductance alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:
a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

E. Chemical Solution Tanks:
1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 30 gal..

F. Chemical Solution Injection Pumps:
1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

G. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

H. Injection Assembly:
1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.4 CHEMICALS

A. Chemicals shall be recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 “Performance Requirements” Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water, and equipped with the following:
1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
2. Install water meter in makeup water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.

4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results for HVAC."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."

E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

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."

3.4 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. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been

cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.

3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. 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 test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. At six-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:
1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Division 01 Section "Demonstration and Training."

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 232500

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes single-wall round duct and fittings and associated sealants, gaskets, hangers and supports for laboratory fume exhaust service.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints for laboratory exhaust systems shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
   1. Seismic Hazard Level C: Importance factor 1.5.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.3 SUBMITTALS

A. Product Data: For each type of the following products:
   1. Duct
   2. Adhesive
   3. Sealants and gaskets.
   4. Seismic-restraint devices.

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Factory- and shop-fabricated ducts and fittings.
   3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   4. Elevation of top of ducts.
   5. Dimensions of main duct runs from building grid lines.
   6. Fittings.
   7. Reinforcement and spacing.

8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. 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.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

E. Welding certificates.

F. Field quality-control reports.

1.4 CONSTRUCTION PROGRESS SUBMITTALS

A. Leakage Test Report: Documentation of work performed for compliance with ASHRAE 90.1, Section 6.4.4.2.2 – “Duct Leakage Tests.”

1.5 CLOSEOUT SUBMITTALS

A. As-built Documents: Provide revised construction drawings to indicate the installed conditions as part of the complete HVAC As-Built Drawing set. The as-built drawings shall be professionally drafted and noted so they are easily read by others.

1.6 QUALITY ASSURANCE

A. 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 D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 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 with he following exceptions:
   1. Minimum Sheet Metal Thickness:
      a. Stainless Sheet Steel: 0.025-inches

B. General Cleanliness Requirements: Comply with SMACNA’s “Duct Cleanliness for New Construction Guidelines”.
   1. Internal surfaces shall be wiped clean after fabrication prior to sealing for shipment.
   2. Self-adhesive labels may be affixed to only the outside surfaces of the duct.

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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."

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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."

E. 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 2, "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."

2.2 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.
      f. Hamlin Sheet Metal

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," 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.

D. Spiral Seams: Select seam types and fabricate according to SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible,” Round Duct Spiral 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.”

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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."

F. Duct Dimensions: Dimensions in the construction documents indicates as follows:
1. Round Duct: Nominal inside diameter of the duct.

2.3 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. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 4.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; stainless steel black and galvanized, steel selected to match duct material.
1. Where black and galvanized-steel shapes and plates ar eused to reinforce aluminum ducts. Isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. 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. Internal tie rods shall not be used on chemical fume hood, biosafety, or specialty exhaust ducts with a duct dimension less than 72 inches.

2.4 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, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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. 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, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. 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.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

D. 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.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:
1. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

PART 3 - EXECUTION

3.1 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 ducts according to SMACNA’s “Duct Cleanliness for New Construction Guidelines”.
1. Store duct, fittings and accessories on pallets in a clean and dry location.
2. All sections of duct, fittings and accessories shall be sealed for shipping and storage. They may be sealed at all openings with polyethylene film, shrink-wrapped, bagged or equivalent. Exposed openings shall remain sealed until temporary filtration is in place.
3. Internal surfaces shall be wiped clean as each is installed to prevent construction dust and debris from accumulating.

D. Install round ducts in maximum practical lengths.

E. Install ducts with fewest possible joints.

F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

K. 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.

L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 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.

3.3 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."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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 10 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.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 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. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 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 100% of supply, return, exhaust, relief, and ventilation duct at pressures equal to their maximum static pressure classifications. Do not over-pressurize systems above their maximum designed operating pressure.
3. Test duct leakage per 2013 ASHRAE Fundamentals Handbook Chapter 21 and 2016 ASHRAE HVAC Systems and Equipment Handbook Chapter19 with an average leakage rate for each duct system as specified in Table 3 for the leakage class specified in Part 3 of this section
4. 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 wg or 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 wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
5. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
6. Test for leaks before applying external insulation.
7. 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.
8. Give 10 days' advance notice for testing.
9. Testing performed prior to the installation of duct accessories, such as dampers and access doors is not valid. Alterations of the systems due to incomplete or non-conforming work made after the testing will void previous test results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting

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.

3.8 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 Division 23 Section "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.

3.9 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts to the requirements indicated:
   1. All Soil Laboratory ICP Fume Exhaust Air **(EF-1),** and Plant Laboratory ICP Fume Exhaust Air within 25 feet of ICP Connections **(EF-9)**
      a. Construction: Single-wall Type 316 stainless steel with No.4 finish when exposed-to-view and No. 2 finish when concealed.
         1) Round duct shall have longitudinal seams.
      b. Static Pressure Class: 4-inches w.g.
      c. SMACNA Seal Class: Welded seams, joints, and penetrations.
      d. SMACNA Leakage Class: 2
   2. Laboratory Fume Hood Scrubber Exhaust Air – Above roof **(EF-10, EF-11)**
      a. Construction: Single-wall Type 316 stainless steel with No.4 finish when exposed-to-view and No. 2 finish when concealed.
         1) Round duct shall have longitudinal seams.
      b. Static Pressure Class: 6-inches w.g.
      c. SMACNA Seal Class: Welded seams, joints, and penetrations.
      d. SMACNA Leakage Class: 2
   3. Plant Laboratory ICP Fume Exhaust Air greater than 25 feet of ICP Connections, Laboratory Fume Hood Exhaust Air, and MARS Fume Exhaust Air **(EF-2, EF-4, EF-8, EF-9, EF-12, and EF-14)**
      a. Construction: CPVC duct
      b. Static Pressure Class: 4-inches w.g.
      c. SMACNA Seal Class: Welded seams, joints, and penetrations.
      d. SMACNA Leakage Class: 2
   4. Laboratory Fume Hood Exhaust Hood Scrubber Exhaust Air – Below Roof **(EF-10, EF-11)**
      a. Construction: CPVC duct
      b. Static Pressure Class: 6-inches w.g.
      c. SMACNA Seal Class: Welded seams, joints, and penetrations.

d. SMACNA Leakage Class: 2

5. Sample Dryer Exhaust Air: **(EF-7)**
   a. Construction: Single-wall Type 304 stainless sheet steel when concealed. Single-wall Type 316 stainless steel with No.4 finish when exposed-to-view.
      1) Round duct shall have longitudinal seams.
   b. Static Pressure Class: 4-inches w.g.
   c. SMACNA Seal Class: Welded seams, joints and penetrations.
   d. SMACNA Leakage Class: 2

B. Intermediate Reinforcement: Match duct material.

C. Double-Wall Duct Interstitial Insulation:
   1. Exhaust-Air Ducts: 2 inches thick.

D. Elbow Configuration:
   1. Metallic 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 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
   2. Metallic 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: Welded.

E. Branch Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
      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 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Combination fire and smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. 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.
1) Fire-damper and combination fire- and smoke-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
d. Wiring Diagrams: For power, signal, and control wiring.

C. 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.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.3 QUALITY ASSURANCE

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 AMCA 500-D testing for damper rating.

1.4 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 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: G90.
   2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. 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.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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. Greenheck Fan Corporation.
3. Lloyd Industries, Inc.
4. Nailor Industries Inc.
5. Ruskin Company.
6. SEMCO Incorporated.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.052-inch- thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch width, 0.050-inch- thick aluminum sheet with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:
1. Material: Stainless steel.
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball.

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. Front of rear screens.
5. 90-degree stops.

N. Sleeve: Minimum 20-gage thickness.

2.3 MANUAL VOLUME DAMPERS

A. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flexmaster U.S.A., Inc.
1) McGill AirFlow LLC.

b. METALAIRE, Inc.
c. Nailor Industries Inc.
1) Pottorff; a division of PCI Industries, Inc.
d. Ruskin Company.

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames:
a. Hat shaped.
b. Stainless-steel channels, 0.064 inch thick.
c. Mitered and welded corners.
d. 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. Stainless, roll-formed steel, 0.064 inch thick.
6. Blade Axles: Stainless steel.
7. Bearings:
a. Stainless-steel sleeve.
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. Blade Seals: Neoprene.
9. Jamb Seals: Cambered stainless steel.
10. Tie Bars and Brackets: Galvanized steel.
11. Accessories:
a. Include locking device to hold single-blade dampers in a fixed position without vibration.

B. Jackshaft:
1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Duro Dyne Inc.
   2. Flexmaster U.S.A., Inc.
   3. Greenheck Fan Corporation.
   4. McGill AirFlow LLC.
   5. METALAIRE, Inc.
   6. Metal Form Manufacturing, Inc.
   7. Nailor Industries Inc.
   8. NCA Manufacturing, Inc.
   9. Ruskin Company.
   10. Vent Products Company, Inc.

B. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:
   1. Hat shaped.
   2. Stainless-steel channels, 0.064 inch thick.
   3. Mitered and welded corners.

D. Blades:
   1. Multiple blade with maximum blade width of 8 inches.
   2. Parallel-blade design.
   3. Stainless steel.
   4. 0.064 inch thick.
   5. Blade Edging: Closed-cell neoprene edging.
   6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
   1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:
   1. Stainless-steel sleeve.
   2. 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.
   3. Thrust bearings at each end of every blade.

2.5 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. NCA Manufacturing, Inc.
3. Pottorff; a division of PCI Industries, Inc.
4. Ruskin Company.

B. Type: Static; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours. 3 hour damper shall be installed where required by the wall or floor rating.

E. FrameCurtain 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: 0.052 or 0.138 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.

2.6 COMBINATION FIRE AND 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. Nailor Industries Inc.
3. Ruskin Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

I. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

J. Leakage: Class I.

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

M. Damper Motors: Two-position action.

N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "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 Division 26 Sections.
   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 lbf and breakaway torque rating of 300 in. x lbf.
   7. Electrical Connection: 115 V, single phase, 60 Hz.

O. Accessories:
   1. Auxiliary switches for position indication.
   2. Test and reset switches, remote mounted.

2.7 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: Roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.8 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. METALAIRE, Inc.
   4. SEMCO Incorporated.
   5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. 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 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cesco Products; a division of Mestek, Inc.

2. Ductmate Industries, Inc.
3. Flexmaster U.S.A., Inc.
4. Greenheck Fan Corporation.
5. McGill AirFlow LLC.
6. Nailor Industries Inc.
7. Pottorff; a division of PCI Industries, Inc.
8. Ventfabrics, Inc.
9. 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 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - 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.

C. Pressure Relief Access Door:
1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 10-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.10 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 0.0428-inch stainless steel.

D. Fasteners: Stainless 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.

2.11 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. Ventfabrics, Inc.
4. 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 5-3/4 inches wide attached to 2 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. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Corrosive and Laboratory Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
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.

H. 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.

2.12 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, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

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.

2.13 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

3.1 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 backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. 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.
   1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts. "Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Connect ducts to duct silencers rigidly.

I. 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. Downstream from manual volume dampers, control dampers and equipment.
   3. 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.
   4. At each change in direction and at maximum 50-foot spacing.
   5. Upstream of turning vanes.
   6. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. 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.

L. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

P. Connect diffusers or light troffer boots to low-pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

Q. Connect flexible ducts to metal ducts with draw bands.

R. Install duct test holes where required for testing and balancing purposes.

S. 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.

3.2 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, smoke, and combination 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.

END OF SECTION 233000

SECTION 230553 - FIBERGLASS REINFORCED PLASTIC CENTRIFUGAL UTILTIY FANS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. FRP Medium Pressure Centrifugal Fans.

1.2 RELATED WORK

A. All sections, drawing plans, and contract documents.

1.3 REFERENCES

A. AMCA -99-10 - Standards Handbook.

B. AMCA 204-05 - Balance Quality and Vibration Levels for Fans.

C. AMCA 205-12 – Energy Efficiency Classification for Fans.

D. AMCA 210-07 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

E. AMCA 211-13 – Certified Ratings Program - Product Rating Manual for Fan Air Performance.

F. AMCA 260-13 - Laboratory Methods of Testing Induced Flow Fans for Rating.

G. AMCA 300-08 - Reverberant Room Method for Sound Testing of Fans.

H. AMCA 311-05 - Certified Ratings Program.

I. AFMBA - Method of Evaluating Load Ratings of Bearings (ASA - B3.11).

J. ASTM D4167-97 - Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.

1.4 QUALITY ASSURANCE

A. Performance ratings: Conform to AMCA standard 205, 211, and 311. All fans shall be licensed to bear the AMCA ratings seal for FEG ratings (AMCA 205), Air Performance (AMCA 210) and Sound Performance (AMCA 300).

B. Classification for Spark Resistant Construction; Conform to AMCA 99.

C. All fans prior to shipment shall be completely assembled and test run as a unit at the specified operating speed or maximum RPM allowed for the particular construction type. Each wheel shall

be statically and dynamically balanced in accordance with ANSI/AMCA 204 “Balance Quality and Vibration Levels for Fans” to Fan Application Category BV-3, Balance Quality Grade G6.3. Balance readings shall be taken by electronic type equipment in the axial, vertical, and horizontal directions on each of the bearings. Records shall be maintained and a written copy shall be available upon request.

1.5 SUBMITTALS

A. Provide dimensional drawings and product data on each CNW fan.

B. Provide fan curves for each fan at the specified operating point, with the flow, static pressure and horsepower clearly plotted.

C. Provide AMCA Certified FEG minimum acceptable rating values of the following:
   1. FEG 67 (CNW 200 to CNW 315)

D. Strictly adhere to QUALITY ASSURANCE requirements as stated in section 1.04 of this specification.

PART 2 - EQUIPMENT

2.1 BASIS OF DESIGN PRODUCT

A. Basic of Design Product: Subject to Compliance with Requirements, Provide Mk Plastics CNW Fan or Approved Equal By:
   1. Loren Cook
   2. Greenheck

2.2 GENERAL

A. Base fan performance at standard conditions (density 0.075 Lb/ft3)

B. Fans selected shall be capable of accommodating static pressure and airflow of scheduled values.

C. Each fan shall be belt drive in arrangement #10, direct drive arrangement #4 or according to drawings.

D. Fasteners to be 304 stainless steel.

E. UV inhibitors are added to the resins and are flame retardant class 1 of 25 or less.

2.3 FAN HOUSING

A. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence. Casings to be smooth exterior and resin rich interior.

B. Fan housing shall be manufactured in specifically formulated resins, for maximum corrosion resistance, and reinforced with fiberglass for structural strength. Fastening bolts holding the casing to the support plate are to be encapsulated in FRP. No uncoated metal fan parts in the corrosive air stream will be tolerated.

C. CNW fans to be supplied with a graphite liner and grounding strap to remove static electricity, if scheduled.

D. Inside the casing, a FRP ridge to be attached to divert condensation from dripping over the hub.

E. When specified, provide a casing drain attached to the casing at the lowest point for condensation removal.

F. Fan outlet to be flanged. Fan inlet to be slip connection.

G. An access door, when requested, shall be supplied for impeller inspection and service.

H. Standard finish color to be light gray.

I. Hub seal to be neoprene or Teflon (when required).

J. M. K. Plastics when requested will supply a Vacuum Hub Seal to avoid any contaminated air from escaping (patent pending).

2.4 FAN IMPELLER

A. Impellers should be solid molded FRP With radial tip curved blades. FRP hub to have a tight fitting cap to protect shaft end. The hub to extend outside the casing. Impellers manufactured in steel and coated with a plastic material are not acceptable. All wheels shall be statically and dynamically balanced on precision electronic balancers to a Balance Quality Grade G6.3 per ANSI/AMCA 204 or better.

2.5 BASE SUPPORT

A. Arr. #10 support to be manufactured in formed steel and to be baked polyester coated. Arr. #4 support to be FRP, depending on motor size.

B. An access panel to be standard to provide accessibility to the motor junction box.

C. An FRP weather cover to be provided with adequate motor ventilation.

2.6 FAN MOTORS AND DRIVES

A. Motors to be TEFC with a 1.15 service factor, or accordance to fan schedule.

B. Belts and pulleys are to be accessible for service and maintenance.

C. CNW fans to have self-lube, cast iron, pillow block bearings.

D. Shafts to be AISI -1045 carbon steel. The shaft shall not be in the corrosive air stream.

E. All bearings to have a minimum L-10 life of 200,000 hours life.

F. Drive guard to be supplied and manufactured according to OSHA standards.

G. Motor sheaves shall be cast iron, variable pitch on applications 5 HP and smaller, and fixed pitch on 7.5 HP and larger.

END OF SECTION 230553

SECTION 233416 - INLINE CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Fiberglass Reinforced Plastic (FRP), Bifurcated Inline Centrifugal Fans.

1.2 RELATED WORK

A. All sections, drawing plans, specifications and contract documents.

1.3 REFERENCES

A. AMCA -99 Standards Handbook

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 211 - Certified Ratings Procedure.

D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

E. AMCA 311 - Certified Sound Ratings Program for Air Moving Devices.

F. AFMBA - Method of Evaluating Load Ratings of Bearings (ASA - B3.11).

G. AMCA 204 - Balance Quality and Vibration Levels for Fans.

1.4 1QUALITY ASSURANCE

A. Performance ratings: Conform to AMCA standard 211 and 311.

B. Classification for Spark Resistant Construction Conform to AMCA 99.

C. Each fan shall be tested before shipping. Motors to be tested for amperage draw.

D. A certificate shall be supplied for each fan, certifying quality control and compliance to specifications, prior to shipping.

1.5 SUBMITTALS

A. Provide dimensional drawings and product data on each fan assembly.

B. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted.

PART 2 - PRODUCTS

2.1 BASIS OF DESIGN PRODUCT

A. Basic of Design Product: Subject to Compliance with Requirements, Provide Mk Plastics AXCL Fan or Approved Equal By:
   1. Loren Cook
   2. Greenheck

2.2 GENERAL

A. Base fan performance at standard conditions (density 0.075 Lb/ft3).

B. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

C. Each fan shall be belt or direct driven in AMCA arrangements as stated in the specs or on the drawings.

D. Fans to be equipped with lifting lugs.

E. Motor mounting plate / bearing mounting plate to be coated steel with a minimum of 4-6 mils of chemical resistant epoxy.

F. Fasteners to be 304 stainless steel.

G. UV inhibitors are added to the resins and are flame retardant class 1 of 25 or less.

2.3 FAN HOUSING

A. Fan housing shall be of the bifurcated design, in which all impeller drive components are outside of the corrosive, contaminated air stream. Housing as well as air inlet shall be aerodynamically designed for high-efficiency, engineered to reduce incoming air turbulence. Housings shall be resin rich to be smooth exterior and interior.

B. Fan housing shall be manufactured in specifically formulated resins, for maximum corrosion resistance, and reinforced with fiberglass for structural strength. Fastening bolts holding the casing to the support plate are to be encapsulated in FRP. No uncoated metal fan parts in the corrosive air stream will be tolerated.

C. Fans shall be supplied with a internal graphite liner and grounding strap to remove static electricity, if scheduled.

D. For horizontal airflow applications, a casing drain for condensation removal shall be an integral part of the fan housing, and attached to the casing at the lowest point.

E. Fan inlet & outlet to be slip connections or flanged.

F. A housing access door shall be supplied for impeller inspection and service.

G. Hub seal to be neoprene or Teflon (when required).

H. AXCL fans shall be supplied with horizontal or vertical mounting brackets, if stated and shown on the plans and specifications.

I. Roof mounted fans shall be supplied with FRP curb caps and discharge butterfly dampers, if stated and shown on the plans and specifications.

J. M. K. Plastics (when specified) will supply a Vacuum Hub Seal to avoid any contaminated air from escaping (patent pending)

K. Finish color to be light gray.

2.4 FAN IMPELLER

A. For AXCL 1225 and 1500, the impellers to be molded FRP, backward inclined. The impellers of the AXCL 1825 and larger to be airfoil, backward inclined, manufactured in solid FRP, unitary construction, with smooth surfaces. A metal backplate integral to the FRP impeller and encapsulated in resin shall have the hub extending to the outside of the fan housing. The shaft end in the housing to be covered by a tight fitting FRP cap. Impellers manufactured in steel and coated with a plastic material are not acceptable.

B. The impellers shall be electronically balanced both statically and dynamically Grade G6.3 per AMCA 204 Standard and conform to ASTM Standard D-4167.

2.5 FAN MOTORS AND DRIVE.

A. Motors to be premium efficiency, standard NEMA frame, 1800 RPM (Belt Drive) or 900, 1200, or 1800 RPM (Direct Drive), TEFC with a 1.15 service factor.

B. A factory mounted NEMA 3R disconnect switch shall be provided for each fan.

C. Belt drive units shall have belts and sheaves sized for 150% of the fan operating brake horsepower, and shall be readily and easily accessible for service.

D. Drives up to 5 HP shall be provided with variable pitch sheave.

E. Shaft to be ANSI C-1045 steel, and be protected with TECTYL 822B protective coating.

F. Shafts to be AISI -1045 carbon steel. The shaft shall not be in the corrosive air stream.

G. Belt driven AXCL fans shall have shaft bearings sized for a minimum life of L-10 100,000 hours. Bearings shall be ball or spherical pillow block type, sealed to retain lubricant and exclude dust and air. Due to the bifurcated fan housing design, bearing inspection and relubrication shall be accomplished without fan disassembly, and in clear view, without the use of extended lube lines.

H. Belt drive guards and motor covers shall be supplied, as indicated on the schedule.

PART 3 - INSTALLATION

A. Install fans as indicated, with resilient mountings and flexible electrical leads.

B. Pipe housing drain to nearest drain.

C. Install fans in accordance with manufacturer’s instructions.

END OF SECTION 233416

SECTION 236426 - Variable Speed Air-cooled Screw Compressor Chiller

PART 1 - GENERAL

1.1 SUMMARY

A.

B. Section includes design, performance criteria, refrigerants, controls, and installation requirements for air-cooled rotary screw packaged chillers.

1.2 REFERENCES

A. AHRI 550/590 - Standard for Water Chilling Packages using the Vapor Compression Cycle

B. AHRI 370 - Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment

C. ASHRAE 15 - Safety Code for Mechanical Refrigeration

D. ASHRAE 90.1 - Energy Efficient Design of New Buildings

E. ASME - Boiler and Pressure Vessel Code SEC VIII, Division 1

F. UL 1995 - Central Cooling Air Conditioners

G. ASTM B117 - Standard Method of Salt Spray (Fog) Testing

H. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

I. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products

J. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments

K. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings.

L. ISO 9001

M. California Administrative Code - Title 24

1.3 SUBMITTALS

A. Submit dimensional plan and elevation view drawings, weights and loadings, required clearances, location and size of all field connections, electrical requirements and wiring diagrams.

B. Submit product data indicating rated capacities, accessories and any special data.

C. Submit manufacturer's installation instructions.

1.4 REGULATORY REQUIREMENTS

A. Comply with codes and standards specified.

B. Chiller must be built in an ISO 9001 classified facility.

1.5 VERIFICATION OF CAPACITY AND EFFICIENCY

A. All proposals for chiller performance must include an AHRI approved selection method. Performance for both full load EER and part load NPLV shall not exceed the efficiency values listed on the equipment schedules at the design temperatures and flow rates.

1.6 DELIVERY, HANDLING AND STORAGE

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting chillers.

B. Chiller shall be capable of withstanding -40°F to 158°F storage temperatures for an indefinite period of time.

1.7 WARRANTY

A. Provide manufacturer’s whole unit parts and labor warranty for one year from start-up or 18 months from shipment, whichever occurs first.

B. Provide manufacturer’s compressor parts only warranty for 5-years from start-up or 66-months from shipment, whichever occurs first.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Basis of Design: Trane

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturer’s:
   1. Trane
   2. Carrier Corporation; a United Technologies company

3. York International Company

2.2 CHILLER DESCRIPTION

A. The contractor shall furnish and install air-cooled water chiller with variable speed screw compressors as shown as scheduled on the contract documents. The chillers shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. The mechanical drawings show the maximum allowable dimensions for the air-cooled chiller. The dimensions shall not be exceeded.

2.3 CHILLER OPERATION:

A. Chiller shall be capable of starting and running at outdoor ambient temperatures from 0°F to 105°F.

B. Low Ambient – The chiller shall include hardware and unit controls to allow start and operation down to ambient temperatures of 0°F.

C. Chiller shall be capable of operating with a leaving solution temperature range 40 to 68°F without glycol.

D. Chiller shall be capable of starting up with 95°F entering fluid temperature to the evaporator. Maximum water temperature that can be circulated with the Chiller not operating is 108°F

E. Chiller shall provide evaporator freeze protection and low limit control to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. Whenever this control is in effect, the controller shall indicate that the chiller is in adaptive mode. If the condition exists for more than 30 seconds, a limit warning alarm relay shall energize.

F. The chiller shall be capable of a 45-second rapid restart after power restoration. The chiller shall be capable of starting in 45 seconds.

2.4 COMPRESSORS

A. Construct chiller using semi-hermetic, variable speed drive, helical rotary screw compressors.

B. Provide compressor motor that is suction gas cooled with robust construction and system design protection.

C. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation.

D. Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.

E. Provide compressor with automatic capacity reduction equipment consisting of capacity control via variable speed drive and/or slide valve. Compressor must start unloaded for soft start on motors.

F. Chiller shall be capable of operation down to 25% load without hot gas bypass.

2.5 EVAPORATOR

A. Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally and externally finned copper tubes, roller expanded into tube sheets. A brazed plate evaporator is not acceptable.

B. The evaporator shall be designed, tested, and stamped in accordance with ASME code for a refrigerant side working pressure of 200 psig. Waterside working pressure shall be 150 psig.

C. Insulate the evaporator with a minimum of 0.75 inch (K=0.28) UV rated insulation. If the insulation is field installed, the additional money to cover material and installation costs in the field should be included in the bid.

D. Evaporator heaters shall be factory installed and shall protect chiller down to -20°F. Contractor shall wire separate power to energize heat tape and protect evaporator while chiller is disconnected from the main power.

E. Provide ability to remove evaporator tubes from the heat exchanger.

F. Evaporator shall have cleanable tubes

G. Provide water drain connection, vent and fittings. Factory installed leaving water temperature control and low temperature cutout sensors.

H. Water connections shall be grooved pipe.

I. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

2.6 FANS

A. Low sound fans shall be balanced and direct driven.

B. All condenser fan TEAO motors have permanently lubricated ball bearings and external overload protection.

C. All condenser fans shall have integrated drives to provide variable speed for optimized efficiency and lower part load sound.

2.7 CONDENSER

A. Construct condenser coils of aluminum fins mechanically bonded to internally finned long life tube alloy. The condenser coils shall have an integral subcooling circuit and shall be designed for 525 psig or higher working pressure.

B. Condenser coils shall be transverse design. If coils are not transverse design, the manufacturer must provide factory installed coil protection for shipping.

2.8 ENCLOSURES/CHILLER CONSTRUCTION

A. Unit panels, structural elements and control boxes are constructed of galvanized steel and mounted on a bolted galvanized steel base. Unit panels, control boxes and the structural base are finished with a baked on powder paint.

B. Control panel doors shall have door stays.

C. Mount starters and Terminal Blocks in a UL 1995 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of chiller indicating if power is on or off.

D. The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B117.

2.9 CHILLER MOUNTED ADAPTIVE FREQUENCEY DRIVE (AFD)

A. The water chiller shall be furnished with a fluid cooled Adaptive Frequency Drive (AFD) as shown on the drawings.

B. The AFD efficiency shall be 97% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.96 at all loads for AFD. All other starters shall have a minimum displacement power factor of 0.85.

C. Power semi-conductor and capacitor cooling shall be from a liquid or air cooled heatsink.

D. Unit shall have a single point power connection.

E. Power line connection type shall be standard with a terminal block.

F. A control power transformer shall be factory-installed and factory-wired to provide unit control power.

G. Unit wiring shall run in liquid-tight conduit

2.10 REFRIGERANT CIRCUIT

A. All chillers shall have 2 refrigeration circuits, with 1 compressor on each circuit.

B. Provide for refrigerant circuit:
   1. Liquid line shutoff valve
   2. Suction service valve
   3. Discharge service valve
   4. Filter (replaceable core type)
   5. Liquid line sight glass.
   6. Electronic expansion valve sized for maximum operating pressure
   7. Charging valve
   8. Discharge and oil line check valves
   9. High side pressure relief valve
   10. Integrated oil loss sensor

C. Full operating charge of R134a and oil.

2.11 CONTROLS

A. A color, touch sensitive liquid crystal display (LCD) shall be unit mounted and a minimum of 7" diagonal. Graphical Icons provide links to sub menus on the subsystems operations.

B. Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor, evaporator, and motor information as well as associated diagnostics.

C. The chiller control panel shall provide password protection of all set points

D. The controller shall have the ability to display all primary sub-system operational parameters on dedicated trending graphs. The operator must be able to create up to 6 additional custom trend graphs, choosing up to 10 unique parameters for each graph to trend log data parameters simultaneously over an adjustable period and frequency polling.

E. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer. The microprocessor and capacity control algorithms shall be capable of handling a maximum of 10% change in water flow rate per minute while maintaining ± 0.5°F leaving evaporator temperature control and shall be capable of handling a maximum of 30% change in water flow per minute while maintaining ± 2°F leaving evaporator temperature control.

F. The front of the chiller control panel shall display the following in clear language, without the use of codes, look-up tables, or gauges:
   1. Run time.
   2. Number of starts.

3. Current chiller operating mode.
4. Chilled water set point and set point source.
5. Electrical current limit set point and set point source.
6. Entering and leaving evaporator water temperatures.
7. Saturated evaporator and condenser refrigerant temperatures.
8. Evaporator and condenser refrigerant pressure.
9. Oil tank pressure.
10. Oil pump sump pressure.
11. Intermediate oil pressure in the compressor.
12. Compressor motor current per phase.
13. Compressor motor percent RLA.
14. Compressor motor voltage per phase.
15. Phase reversal/unbalance/single phasing and over/under voltage protection.
16. Low chilled water temperature protection.
17. High and low refrigerant pressure protection.
18. Load limit functions (both current based or pulldown rate based) to limit compressor loading on high return water temperature.
19. Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize chiller efficiency.
20. Display diagnostics.
21. Oil pressure control based off of maintaining system differential pressure.
22. Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.
23. Oil loss indication.

G. Weatherproof control panel shall be mounted on chiller, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer.

H. The chiller controller shall utilize a microprocessor that will automatically take action to prevent chiller shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.

I. Provide the following safety controls with indicating lights or diagnostic readouts.
1. Low chilled water temperature protection.
2. High refrigerant pressure.
3. Low oil flow protection.
4. Loss of Oil diagnostic
5. Loss of chilled water flow.
6. Contact for remote emergency shutdown.
7. Motor current overload.
8. Phase reversal/unbalance/single phasing.
9. Over/under voltage.
10. Failure of water temperature sensor used by controller.
11. Compressor status (on or off).

J. Provide the following operating controls:
   1. A variable method to control capacity in order to maintain leaving chilled water temperature based on PI algorithms. Five-minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5-minute start-to-start.
   2. Chilled water pump output relay that closes when the chiller is given a signal to start.
   3. Load limit functions to limit compressor loading on high return water temperature to prevent nuisance trip outs.
   4. High condenser pressure limit controls that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
   5. Compressor current limit controls that unloads compressors to help prevent current overload nuisance trip outs.
   6. Low ambient lockout control with user adjustable set point.
   7. Condenser fan sequencing which adjusts the speed of all fans automatically in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing chiller efficiency.

K. Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:
   1. Leaving chilled water set point adjustment from touch panel input
   2. Entering and leaving chilled water temperature output
   3. Percent RLA output for each compressor
   4. Pressure output of condenser
   5. Pressure output of evaporator
   6. Ambient temperature output
   7. Voltage output
   8. Current limit set point adjustment from LCD input.

L. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.

2.12 SOUND

A. Provide Invisisound Superior Acoustic treatment consisting of insulating sound material applied to the suction and discharge line.

B. A-weighted sound pressure shall not exceed 71dBA and A-weighted sound power must not exceed 98dBA. Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels, per AHRI 370. A-weighted sound pressure at 30 feet should be provided at 100%, 75%, 50% and 25% load points to identify the full operational noise envelope. If manufacturer cannot meet the noise levels, sound attenuation devices and/or barrier walls must be installed to meet this performance level.

C. Chiller shall ship with a muffler on each rotary screw compressor and very low noise condenser fans to meet the scheduled sound levels. If chiller does not meet sound levels, chiller manufacturer shall provide additional attenuation features.

2.13 FACTORY INSTALLED ACCESSORIES

A. Circuit Breaker - A molded case standard interrupting capacity circuit breaker shall be factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, making it available to disconnect the chiller from main power.

B. 65,000A High Short Circuit Current Rating (SCCR) - High short circuit current rating (SCCR) of 65kA with selection of high fault protection device.

C. Convenience Outlet - Provide a factory-installed, field-wired 15 amp, 115-volt GFCI convenience outlet shall be factory mounted on the exterior of the control panel. A separate 115V/1ph circuit is required to be provided by the electrical contractor.

D. BACnet Interface – The chiller shall be provided with digital communications to BAS system shall consist of a BACnet MS/TP interface via a single twisted pair wiring.

E. Alarm Relay Panel - The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

F. Condenser Coil Guards / Louvered Panels - Chiller shall have full architectural louvers panels covering from the top of the unit to the base rail.

G. Elastomeric Isolators - Chiller shall ship with elastomeric Isolators for field installation by the mechanical contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's requirements.
   1. Level the chiller using the base rail as a reference. The chiller must be level within ½ in over the entire length and width. Use shims as necessary to level the chiller.

3.2 SERVICE AND START-UP

A. Startup - Provide all labor and materials to perform startup. Startup shall be performed by a factory-trained technician from the original equipment manufacturer (OEM). Technician shall confirm that equipment has been correctly installed and passes specification checklist prior to equipment becoming operational and covered under OEM warranty. This shall be done in strict

accordance with manufacturer's specifications and requirements. Third-party service agencies are not permitted.

B. A start-up log shall be furnished by the factory approved start-up technician to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.

C. Chiller manufacturers shall maintain service capabilities no more than 50 miles from the jobsite.

END OF SECTION 236426

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulation for HVAC piping systems.

B. Related Requirements:
1. Section 230713 "Duct Insulation" for duct insulation.
2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.
3. Section 232113.13 "Underground Hydronic Piping" loose-fill pipe insulation in underground piping outside the building.
4. Section 232213.13 "Underground Steam and Condensate Heating Piping" for steam and condensate piping for steam-type tank heaters.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. 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.

C. Field quality-control reports.

1.5 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.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing 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. 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.

1.6 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.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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.

C. Coordinate installation and testing of heat tracing.

1.8 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

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate: Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
   1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
   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. Johns Manville; a Berkshire Hathaway company

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:
      a. Owens Corning
      b. Pittsburgh Corning Corporation
   2. Preformed Pipe Insulation without Jacket: Type II, Class 1, without jacket.
   3. Preformed Pipe Insulation with Jacket: Type II, Class 2, with factory-applied ASJ jacket.
   4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
   5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials, Type II for sheet materials.
   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. Aeroflex USA

b. Armacell LLC
c. K-Flex USA

I. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.
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. Johns Manville; a Berkshire Hathaway company.
b. Knauf Insulation
c. Manson Insulation Inc.
d. Owens Corning
2. Preformed Pipe Insulation: Type I, Grade A, with factory-applied ASJ.
3. 850 deg F.
4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe and Tank: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C1393.
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. CertainTeed Corporation; Saint-Gobain North America
b. Johns Manville; a Berkshire Hathaway company
c. Knauf Insulation
d. Manson Insulation Inc.
e. Owens Corning
2. Semirigid board material with factory-applied ASJ jacket.
3. Nominal density is 2.5 lb/cu. ft. or more.
4. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.
5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Phenolic: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C1126.
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. Resolco Inc.
2. Preformed Pipe Insulation: Type III, with factory-applied ASJ.
3. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. Polyisocyanurate: Preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation. Comply with ASTM C591.

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. Johns Manville; a Berkshire Hathaway company
   b. Dow Chemical Company
   c. ITW Insulation Systems; Illinois Tool Works, Inc.
2. Preformed insulation, with field-applied jacket.
3. Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
4. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thicknesses of up to 1 inch as tested in accordance with ASTM E84.
5. Fabricate shapes in accordance with ASTM C450 and ASTM C585.
6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

M. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534/C534M or ASTM C1427, Type I, Grade 1, for tubular materials and with Type II, Grade 1, for sheet materials.
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. Armacell LLC

N. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes in accordance with ASTM C450 and ASTM C585.
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. ITW Insulation Systems; Illinois Tool Works, Inc.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
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. Ramco Insulation, Inc.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
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. Ramco Insulation, Inc.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

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. Ramco Insulation, Inc.

2.3 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. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
   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. Childers Brand; H. B. Fuller Construction Products
      b. Foster Brand; H. B. Fuller Construction Products
      c. Mon-Eco Industries, Inc.
      d. Vimasco Corporation

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
   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. Foster Brand; H. B. Fuller Construction Products

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
   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. Childers Brand; H. B. Fuller Construction Products
      b. Foster Brand; H. B. Fuller Construction Products

E. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
   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. Aeroflex USA
      b. Armacell LLC
      c. Foster Brand; H. B. Fuller Construction Products
      d. K-Flex USA
   2.
   3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
   4. Wet Flash Point: Below 0 deg F.

5. Service Temperature Range: 40 to 200 deg F.
6. Color: Black.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
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. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products
c. Mon-Eco Industries, Inc.

G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F
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. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products

H. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
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. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products
c. Mon-Eco Industries, Inc.

I. PVC Jacket Adhesive: Compatible with PVC jacket.
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. Johns Manville; a Berkshire Hathaway company
b. P.I.C. Plastics, Inc.
c. Speedline Corporation
d. The Dow Chemical Company

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products

c. Knauf Insulation
d. Vimasco Corporation
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products
c. Mon-Eco Industries, Inc.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to 180 deg F.
4. Color: White.

D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products
c. Knauf Insulation
d. Mon-Eco Industries, Inc.
e. Vimasco Corporation
2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.5 LAGGING ADHESIVES

A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products
   b. Foster Brand; H. B. Fuller Construction Products
   c. Vimasco Corporation
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 20 to plus 180 deg F
4. Color: White.

2.6 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products
   b. Foster Brand; H. B. Fuller Construction Products
   c. Mon-Eco Industries, Inc.
   d. Pittsburgh Corning Corporation
2. Permanently flexible, elastomeric sealant.
   a. Service Temperature Range: Minus 150 to plus 250 deg F.
   b. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products
   b. Foster Brand; H. B. Fuller Construction Products
   c. Mon-Eco Industries, Inc.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F
4. Color: Aluminum.

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.7 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 C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd.with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Foster Brand; H. B. Fuller Construction Products
      b. Vimasco Corporation

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Alpha Associates, Inc.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Airex Manufacturing
b. Johns Manville; a Berkshire Hathaway company
c. P.I.C. Plastics, Inc.
d. Proto Corporation
e. Speedline Corporation

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Engineer.
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, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:
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. ITW Insulation Systems; Illinois Tool Works, Inc.
   b. RPR Products, Inc.
2. Aluminum Jacket: Comply with ASTM B209, 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: 3-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 two-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.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division
   b. Avery Dennison Corporation, Specialty Tapes Division

c. Ideal Tape Co., Inc., an American Biltrite Company
d. Knauf Insulation

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. 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 C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M Industrial Adhesives and Tapes Division
b. Avery Dennison Corporation, Specialty Tapes Division
c. Ideal Tape Co., Inc., an American Biltrite Company
d. Knauf Insulation
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. 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. 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. 3M Industrial Adhesives and Tapes Division
b. Ideal Tape Co., Inc., an American Biltrite Company
2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M Industrial Adhesives and Tapes Division
b. Avery Dennison Corporation, Specialty Tapes Division
c. Ideal Tape Co., Inc., an American Biltrite Company
d. Knauf Insulation
2. Width: 2 inches.
3. Thickness: 3.7 mils.

4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.
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. C & F Wire

PART 3 - EXECUTION

3.1 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 to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature of 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 tradesman 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.

3.3 GENERAL INSTALLATION REQUIREMENTS

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

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of 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 dry during storage, application, and finishing. Replace insulation materials that get wet.

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 attached to structure with vapor-barrier mastic.
3. Install insert materials and 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 4 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, in accordance with 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 25 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 in similar fashion 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.

3.4 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.
1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 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, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of 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 of same material and thickness as that 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 of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
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 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.

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. Install removable insulation covers. 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 that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure single-layer insulation with stainless steel bands at 12-inch intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

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 cut sections of block insulation of same material and thickness as that of pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.

3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of 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 services, secure laps with outward-clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient services, 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 cut sections of cellular-glass block insulation of same thickness as that of pipe 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 that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of cellular-glass 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.

3.8 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 that of 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 that of 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.

3.9 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 that of 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 that of 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.

3.10 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:
1. Secure single-layer insulation with stainless steel bands at 12-inch intervals, and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of 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 services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, 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.

C. 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 cut sections of block insulation of same material and thickness as that of pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
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.

3.11 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, and same thickness as that 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 that of pipe insulation.

C. Insulation Installation on Fittings and Elbows:
1. Install preformed sections of same material as that of 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.

3.12 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Seal split-tube 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 polyolefin sheet insulation of same thickness as that of 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 polyolefin 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 cut sections of polyolefin pipe and sheet 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.
   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.

3.13 INSTALLATION OF POLYSTYRENE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation with tape or bands and tighten bands 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, and make thickness same as that of adjacent pipe insulation, not to exceed 1-1/2 inches.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness that of as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed section of polystyrene 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.

3.14 INSTALLATION OF FIELD-APPLIED JACKETS

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 and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. 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.

3.15 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
   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 as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless steel jackets.

3.16 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. Engage a qualified testing agency to perform tests and inspections.

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

D. Perform tests and inspections.

E. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, 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.

F. All insulation applications will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.17 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. 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.

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 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: 1 inch thick.

B. Chilled Water and Brine, Above 40 Deg F:
1. NPS 12 and Smaller: Insulation shall the following:
a. Polyisocyanurate: 2 inch thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
1. NPS 12 and Smaller: Insulation shall be one of the following:
a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

D. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1 inch thick.

E. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 2 inches thick.

F. Refrigerant Liquid Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1 inch thick.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Cellular Glass: 3 inches thick.
b. Flexible Elastomeric: 3 inches thick.
c. Phenolic: 2 inches thick.
d. Polyisocyanurate: 2 inches thick.
e. Polyolefin: 3 inches thick.
f. Polystyrene: 2 inches thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Cellular Glass: 3 inches thick.
      b. Phenolic: 2 inches thick.
      c. Polyisocyanurate: 2 inches thick.

C. Refrigerant Suction and Hot-Gas Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

D. Refrigerant Suction and Hot-Gas Flexible Tubing:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.
      b.

E. Refrigerant Liquid Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

3.20 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. Piping, Exposed:

   1. PVC, Color-Coded by System: 30 mils thick.

3.21 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. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

   1. Aluminum, Corrugated with Z-Shaped Locking Seam: 0.040 inch thick.

END OF SECTION 230719

SECTION 233116 - NONMETAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes round CPVC duct and fittings and associated sealants, gaskets, hangers and supports for laboratory fume exhaust service:
   1. PVC ducts and fittings.
   2. CPVC ducts and fittings.

B. Related Requirements:
   1. Section 230130.52 "Existing HVAC Air-Distribution System Cleaning" for cleaning of existing HVAC air-distribution equipment, ducts, plenums, and system components.
   2. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration-isolated and restrained ductwork hangers and supports.
   3. Section 230548.13 "Vibration Controls for HVAC" for vibration-isolated ductwork and hangers.
   4. Section 233113 "Metal Ducts" for single- and double-wall, rectangular and round ducts.
   5. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Thermoplastic (PVC) Duct Design: Duct construction, including joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and hangers and supports according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems" and performance requirements and design criteria indicated in "Duct Schedule" Article.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. PVC duct materials.
   2. CPVC duct materials.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevation of top of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated, smoke-rated, and other partitions.
9. Fire and smoke damper locations.
10. Equipment installation based on equipment being used on Project.
11. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for nonmetal ducts, 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.

C. Welding certificates.

D. Field quality-control reports.

1.6 CONSTRUCTION PROGRESS SUBMITTALS

A. Leakage Test Report: Documentation of work performed for compliance with ASHRAE 90.1, Section 6.4.4.2.2 – “Duct Leakage Tests.”

1.7 CLOSEOUT SUBMITTALS

A. As-built Documents: Provide revised construction drawings to indicate the installed conditions as part of the complete HVAC As-Built Drawing set. The as-built drawings shall be professionally drafted and noted so they are easily read by others.

1.8 QUALITY ASSURANCE

A. Hanger and Support Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for steel hangers and supports.
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum hangers and supports.

1.9 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of ductwork system that fail in material or workmanship within specified warranty period.
   1. Warranty Period, HDPE Duct System: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with the following and with the Works' performance requirements and design criteria:
   1. SMACNA's "Thermoplastic Duct (PVC) Construction Manual."
   2. SMACNA's "Thermoset FRP Duct Construction Manual."
   3. Static-Pressure Classes:
      a. Exhaust Ducts (Negative Pressure): 1-inch wg

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 - "Airstream Surfaces."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. NFPA Compliance:
   1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
   2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

2.2 PVC DUCTS AND 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. General Plastics, Inc.
2. GPK Products, Inc.
3. Harrison Machine & Plastic Corporation
4. Harvel Plastics, Inc.
5. Kroy Industries, Inc.
6. Spears Manufacturing Company

B. Duct and Fittings:
1. Material: Rigid, virgin PVC compound complying with ASTM D1784 Cell Classification 12454-B.
2. Flammability: Maximum flame-spread index of not more than 25 without evidence of continued progressive combustion.
3. External Loading Properties: ASTM D2412.
4. Minimum Round Duct Wall Thickness: 0.187 inch for up to 18-inch0.219 inch for up to 20-inch;0.25 inch for up to 24-inch duct.
5. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
6. Rectangular Fittings: Minimum 0.125-inch-thick, flat sheet with heat-formed corners and continuous welded butt joints.

C. Joining Materials: PVC solvent cement complying with ASTM D2564.

D. Fabrication:
1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

E. Drains: PVC drain pockets with a minimum of NPS 1 threaded PVC pipe connections.

2.3 CPVC DUCTS AND 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. Harrison Machine & Plastic Corporation
2. Harvel Plastics, Inc.
3. Spears Manufacturing Company

B. Duct and Fittings:
1. Material: Rigid, virgin CPVC compound complying with ASTM D1784 Cell Classification 23447.
2. Flammability: Maximum flame-spread index of not more than 25 without evidence of continued progressive combustion and a smoke-developed index of not more than 50.
3. Maximum Service Temperature: 200 deg F.
4. External Loading Properties: ASTM D2412.

5. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
6. Rectangular Fittings: Minimum 0.125-inch-thick, flat sheet with heat-formed corners and continuous welded butt joints.

C. Joining Materials: CPVC solvent cement complying with ASTM D2564.
1. Round fittings less than 14” diameter: CPVC primer and heavy-bodied solvent cement complying with IPS 729.

D. Fabrication:
1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."
2. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

E. Drains: CPVC drain pockets with a minimum of NPS 1threaded CPVC pipe connections.

2.4 HANGERS AND SUPPORTS

A. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. 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."

C. Steel Cables: ASTM A492, stainless-steel cables with end connections made of stainless-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports: Steel shapes complying with ASTM A36/A36M.

PART 3 - EXECUTION

3.1 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 "Duct Cleanliness for New Construction Guidelines".
   1. Store duct, fittings and accessories on pallets in a clean and dry location.
   2. All sections of duct, fittings and accessories shall be sealed for shipping and storage. They may be sealed at all openings with polyethylene film, shrink-wrapped, bagged or equivalent. Exposed openings shall remain sealed until temporary filtration is in place
   3. Internal surfaces shall be wiped clean as each is installed to prevent construction dust and debris from accumulating

C. Install duct sections in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a minimum clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. 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. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code and by authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the fire damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

O. Install PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."

P. Install CPVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."

3.2 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.

3.3 HANGER AND SUPPORT INSTALLATION

A. Install hangers and supports for PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."

B. Install hangers and supports for CPVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Ch. 3, "Standards of Construction for PVC Duct Systems."

C. Hanger Spacing: Install hangers and supports for CPVC ducts and fittings to comply with SMACNA’s “ Thermoplastic Duct (PVC) Construction Manual, “ Chapter 3, “Standards of Construction for PVC Duct Systems.”

D. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. 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.

E. 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.

F. Hangers Exposed to View: Threaded rod and angle or channel supports.

G. 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 maximum intervals of 10 feet.

3.4 CONNECTIONS

A. CPVC Ducts: Make connections to equipment with flanged joints.

3.5 STARTUP SERVICE

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.6 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.
1. Leakage Tests:
   a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   b. Test duct leakage per 2013 ASHRAE Fundamentals Handbook Chapter 21 and 2016 ASHRAE HVAC Systems and Equipment Handbook Chapter19 with an average leakage rate for each duct system as specified in Table 3 for the leakage class specified in Part 3 of this section.

c. Where static pressure and leakage values shown below differ from those in the SMACNA manual, the more stringent values shall apply.
d. Test 100% of supply, return, exhaust, relief, and ventilation duct at pressures equal to their maximum static pressure classifications. Do not over-pressurize systems above their maximum designed operating pressure.
e. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
f. Test for leaks before applying external insulation.
g. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
h. Give 10 days' advance notice for testing.
i. Testing performed prior to the installation of duct accessories, such as dampers and access doors is not valid. Alterations of the systems due to incomplete or non-conforming work made after the testing will void previous test results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.

D. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of 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

E. Duct system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DUCT SCHEDULE

A. Fabricate ducts to the requirements indicated:
1. All Soil Laboratory ICP Fume Exhaust Air (EF-1), and Plant Laboratory ICP Fume Exhaust Air within 25 feet of ICP Connections (EF-9)
a. Construction: Single-wall Type 316 stainless steel with No.4 finish when exposed-to-view and No. 2 finish when concealed.
1) Round duct shall have longitudinal seams.
b. Static Pressure Class: 4-inches w.g.
c. SMACNA Seal Class: Welded seams, joints, and penetrations.
d. SMACNA Leakage Class: 2
2. Laboratory Fume Hood Scrubber Exhaust Air – Above roof (EF-10, EF-11)
a. Construction: Single-wall Type 316 stainless steel with No.4 finish when exposed-to-view and No. 2 finish when concealed.

1) Round duct shall have longitudinal seams.

b. Static Pressure Class: 6-inches w.g.

c. SMACNA Seal Class: Welded seams, joints, and penetrations.

d. SMACNA Leakage Class: 2

3. Plant Laboratory ICP Fume Exhaust Air greater than 25 feet of ICP Connections, Laboratory Fume Hood Exhaust Air, and MARS Fume Exhaust Air (EF-2, EF-4, EF-8, EF-9, EF-12, and EF-14)
   a. Construction: CPVC duct
   b. Static Pressure Class: 4-inches w.g.
   c. SMACNA Seal Class: Welded seams, joints, and penetrations.
   d. SMACNA Leakage Class: 2
4. Laboratory Fume Hood Exhaust Hood Scrubber Exhaust Air – Below Roof (EF-10, EF-11)
   a. Construction: CPVC duct
   b. Static Pressure Class: 6-inches w.g.
   c. SMACNA Seal Class: Welded seams, joints, and penetrations.
   d. SMACNA Leakage Class: 2
5. Sample Dryer Exhaust Air: (EF-7)
   a. Construction: Single-wall Type 304 stainless sheet steel when concealed. Single-wall Type 316 stainless steel with No.4 finish when exposed-to-view.
      1) Round duct shall have longitudinal seams.
   b. Static Pressure Class: 4-inches w.g.
   c. SMACNA Seal Class: Welded seams, joints, and penetrations.
   d. SMACNA Leakage Class: 2

B. Intermediate Reinforcement: Match duct material.

C. Double-Wall Duct Interstitial Insulation:
1. Exhaust-Air Ducts: 2 inches thick.

D. Elbow Configuration:
1. Metallic 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 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
2. Metallic 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.
   b. Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

c. Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
d. Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
e. Radius-to Diameter Ratio: 1.5.
f. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
g. Round Elbows, 14 Inches and Larger in Diameter: Welded.

E. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
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 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "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 233116

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: 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. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 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: One set for each air-handling unit.

1.7 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. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 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:
      a. For Compressor: Five years from date of Substantial Completion.
      b. For Parts: Five years from date of Substantial Completion.
      c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 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. Mitsubishi Electric & Electronics USA, Inc.
   2. Trane
   3. Carrier Corporation

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:
   1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
   2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
   3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
   4. Fan: Direct drive, centrifugal.
   5. Fan Motors:
      a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
      b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
      c. Enclosure Type: Totally enclosed, fan cooled.
      d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
      e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
      f. Mount unit-mounted disconnect switches on interior of unit.
   6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
   7. Condensate Drain Pans:
      a. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
         1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
         2) Depth: A minimum of 1 inch deep.
      b. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
   1) Minimum Connection Size: NPS 1.
d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

8. Condensate Pump Section:
   a. General Requirements for Condensate Pump:
      1) Basis of Design: Blue Diamond MaxiBlue Condensate Pump with Reservoir & Sensor
      2) Maximum flow: 3.7 gallons/hour
      3) Maximum head: 23 feet
      4) Maximum lift: 16.5 feet
9. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      1) Comply with NFPA 90A.
      2) Minimum MERV according to ASHRAE 52.2.
      3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
   b. Disposable Panel Filters:
      1) Factory-fabricated, viscous-coated, flat-panel type.
      2) Thickness: 1 inch.
      3) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
      4) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:
1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   a. Compressor Type: Scroll.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant: R-410A.
   d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Low Ambient Kit: Permits operation down to -40 deg F.
6. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely 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.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

G. Monitoring:
   1. Monitor constant and variable motor loads.
   2. Monitor variable-frequency-drive operation.
   3. Monitor economizer cycle.
   4. Monitor cooling load.
   5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 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 roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
2. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply [and return] ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 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.

B. 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.

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.

E. Prepare test and inspection reports.

3.4 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.

3.5 DEMONSTRATION

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

END OF SECTION 238126

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 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.

1.3 ELECTRICAL SUPERINTENDENT REQUIREMENTS

A. Throughout the progress of the work, the electrical contractor shall keep at the job site, a competent superintendent or supervisory staff satisfactory to the designer. The superintendent shall not be changed without the written consent of the designer unless said superintendent ceases to be employed by the contractor or ceases to be competent.

1.4 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. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.
   1. Where electrical j-boxes are required to be installed above non-accessible ceilings, group j-boxes serving the same area together and provide access door.

a. Coordinate location of access door with the Architect prior to installation of circuitry.

1.5 DIVISION OF WORK

A. This section delineates the division of work between Division 23 and Division 26. All electrical work necessary for the proper operation of equipment requiring electrical power and/or controls for this project shall be as described herein.
   1. All individual motor starters, Variable Frequency Drive (VFD), disconnect switches for equipment requiring electrical power shall be furnished and installed by the contractor providing the equipment unless indicated as a part of a motor control center.
      a. Motor starters for mechanical equipment provided in motor control centers shall be furnished under Division 26.
   2. All power wiring up to a termination point consisting of a junction box, trough, starter, VFD or disconnect switch, herein referred to as line side terminations, shall be provided by Division 26.
   3. Wiring from the line side termination point to the mechanical equipment, including final connections, herein referred to as the load side terminations, shall be provided by the contractor providing the equipment.
   4. Fire alarm Air Handling Unit (AHU) shut down circuits shall be wired from the fire alarm control panel to a termination point, adjacent to the AHU control, under Division 26. AHU control wiring from the termination point to the equipment shall be under Division 23 and shall be controlled as indicated on the Division 23 control diagrams.
   5. Equipment operating at less than 110 volts AC, including but not limited to: all relays; actuators; timers; alternators; pressure sensors; vacuum sensors; float sensors; flow switches; pneumatic-electric switches; electric-pneumatic switches; aquastats; freezestats; line and low voltage thermostats; thermals; remote selector switches; remote push-button stations; interlocking devices; indicating lights; and disconnect switches beyond the line side termination point, and other appurtenances associated with equipment that is being provided shall be furnished, installed and wired by the contractor providing said equipment.
   6. All wiring required for HVAC controls and instrumentation not indicated on the drawings shall be furnished and installed by Division 23.
   7. Roof exhaust fans with built-in disconnects provided under Division 23, or doors provided with built-in outlets shall be wired under Division 26 to the line side of the disconnect switch, or the outlet.
   8. A disconnect switch shall be provided under Division 26 if the fan is not provided with a built-in disconnect switch. In this case wiring from the switch to the fan shall be under Division 23.
   9. The sequence of control for all HVAC equipment shall be as indicated on the Division 23 control diagrams and specified in Division 23, HVAC Control System.
   10. Where electrical wiring is required by trades, other than what is specifically indicated in this specification, shall refer to same Division 26 specifications and shall provide required starters, VFD, disconnect switches and controls as has been described herein for contractors providing equipment.

11. All equipment requiring motor starters the contractor providing the equipment shall provide combination starter/disconnects. Individual starters and disconnect switches will not be accepted.
12. Variable Frequency Drive (VFD) shall be provided for all pumps and fan motors that are five H.P and larger.
13. A diagram clarifying which trade/contractor is to provide electrical wiring and/or electrical equipment is shown on the Division 21, 22, 23, 26/28 contract drawings.
14. The contractor providing the equipment requiring starters, VFD, disconnect switches, conduits and conductors shall reference, in its entirety, the specifications of Division 26 and shall install all provided equipment in full compliance with all requirements of Division 26.
15. Where electrical wiring is required by trades other than covered by Division 26, the installer shall refer to the wiring materials and methods as specified under Division 26. No exceptions.

PART 2 - PRODUCTS

3.1 SUBSTITUTIONS

A. In specifying materials where three brand names have not been given the following applies:
   1. When the material or equipment is specified with the phrase "...or approved equal..." after a brand name and other identifying information, it is intended that the brand name is used for the purpose of establishing a minimum acceptable standard of quality and performance and Contractor may base his bid proposal on any item which is in all respects equal to that specified and presents essentially the same appearance. It shall be the Contractor's responsibility to ensure proper fit and clearances of all substituted equipment.

B. All of the following shall be distinctly understood:
   1. The (Architect/Engineer) will use his/her own judgment in determining whether or not any materials, equipment or methods offered in substitution are equal to those specified.
   2. The decision of the (Architect/Engineer) on all such questions of equality is final.
   3. All substitutions will be made at no increase in cost to the Owner.

C. All substitutions must be submitted through the appropriate bidding contractor to the Engineer 10-days prior to the bid date. Substitutions submitted after this time period may be deemed by the Engineer as the sole reason for rejection.

D. Upon receipt of written approval from (Architect/Engineer), Contractor may proceed with substitution providing Contractor assumes full responsibility for, and makes, at his own expense, any changes or adjustments in construction or connection with other work that may be required by the substitution of such materials, equipment or methods. In the event of any adverse decisions by the (Architect/Engineer) no claim of any sort shall be made or allowed against the Owner.

3.2 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 4 - EXECUTION

4.1 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 (Architect/Engineer) listing the manufacturer's torque recommendations at all terminals and verifying the torque completed by the electrician.

4.2 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly.

END OF SECTION 260500

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 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.

1.3 DEFINITIONS

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

B. NBR: Acrylonitrile-butadiene rubber.

1.4 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.

1.5 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.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 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
   6. United Copper Industries
   7. American Bare Copper Incorporated

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.

D. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN

E. Conductor sizes: Minimum conductor size shall be #12 for branch circuits.

2.2 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.

2.3 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.

PART 3 - EXECUTION

3.1 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.

3.2 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 Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

C. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

D. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Class 1 Control Circuits: Type THHN-THWN, in raceway.

F. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 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 120 volt circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

J. Install no more than 3 phase wires in any feeder or branch circuit conduit.

K. Install a dedicated neutral conductor for each single phase 277-volt or 120-volt circuit.

3.4 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. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

D. 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.

E. 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.

F. 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.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of 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. Cut sleeves to length for mounting flush with both wall surfaces.

F. 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.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. 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.

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials.

J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

K. 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.

3.6 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.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

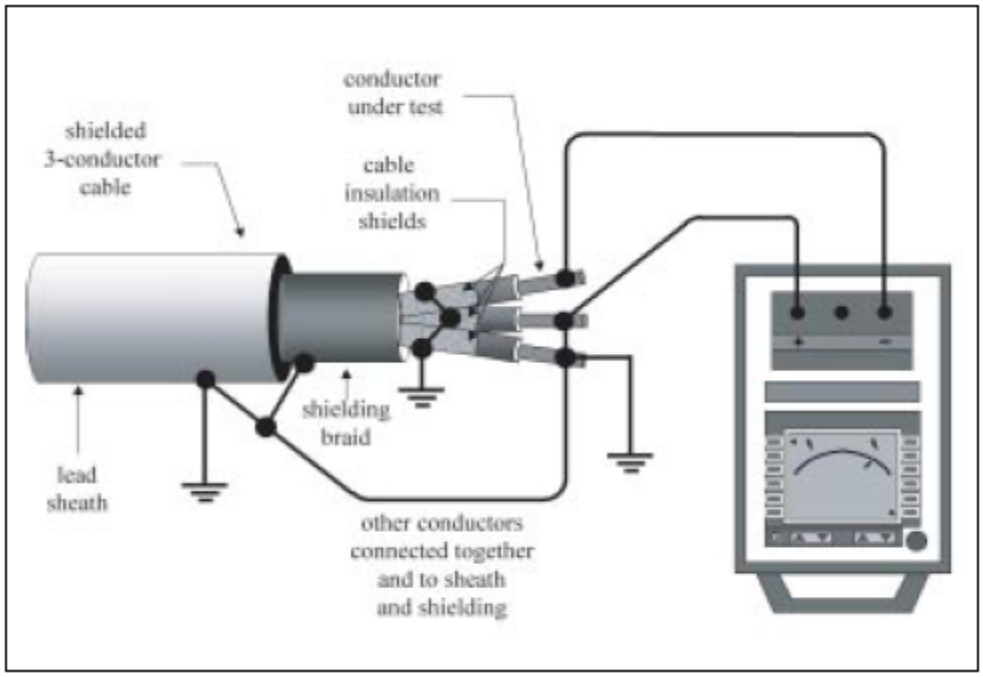
C. Tests and Inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
   2. Prior to energizing feeders, sub-feeders and service conductor, cables shall be tested for electrical continuity and short circuits.
   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.
   4. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. 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.

E. 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 260519

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. 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.

C. 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.

D. Qualification Data: For testing agency and testing agency's field supervisor.

E. Qualification Data: For Exothermic-welding personnel.

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 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Grounding Conductors, Cables, Connectors, and Rods:
      . Apache Grounding/Erico Inc.
      a. Boggs, Inc.
      b. Chance/Hubbell.

c. Copperweld Corp.
d. Dossert Corp.
e. Encore
f. Erico Inc.; Electrical Products Group.
g. Framatome Connectors/Burndy Electrical.
h. Galvan Industries, Inc.
i. Harger Lightning Protection, Inc.
j. Hastings Fiber Glass Products, Inc.
k. Heary Brothers Lightning Protection Co.
l. Ideal Industries, Inc.
m. ILSCO.
n. Kearney/Cooper Power Systems.
o. Korns: C. C. Korns Co.; Division of Robroy Industries.
p. Lightning Master Corp.
q. Lyncole XIT Grounding.
r. O-Z/Gedney Co.; a business of the EGS Electrical Group.
s. Raco, Inc.; Division of Hubbell.
t. Robbins Lightning, Inc.
u. Salisbury: W. H. Salisbury & Co.
v. Southwire Company
w. Superior Grounding Systems, Inc.
x. Thomas & Betts, Electrical.

2.02 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.

2.03 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.

2.04 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. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

D. Conductor Insulation:
   1. Branch circuits and feeder grounding conductors shall be insulated, with green insulation where commonly available or marked at every accessible point with green tape.

E. 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 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits raceways and cables.

3.03 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. 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.

3.04 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. 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.

C. 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.

D. 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.

E. 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.

3.05 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.

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.

END OF SECTION

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 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.

1.5 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.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 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. These items are specified in Division 07 Section "Roof Accessories."

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 Frames."

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. Provide dimensioned layout drawing(s) of main electrical room, generator room, and electrical closet 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.

PART 2 - PRODUCTS

2.1 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 where 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) Hilti Inc.
2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. 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.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 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

3.1 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.

3.2 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 New 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 Existing Concrete: Expansion anchor fasteners.
   5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
   6. To Light Steel: Sheet metal screws.
   7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
   8. Conduits installed in 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.

3.3 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.

3.4 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 260529

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

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

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. LFNC: Liquidtight flexible nonmetallic conduit.

H. NBR: Acrylonitrile-butadiene rubber.

I. RNC: Rigid nonmetallic conduit.

1.4 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.
   2. For handholes and boxes for underground wiring, including the following:

a. Duct entry provisions, including locations and duct sizes.
b. Frame and cover design.
c. Grounding details.
d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
e. Joint details.

C. Coordination Drawings: Conduit routing plans, 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 in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Qualification Data: For professional engineer and testing agency.

E. Source quality-control test reports.

1.5 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

2.1 METAL CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Alflex Inc.
a. Only where aluminum flexible conduit has been specifically listed for use on this project.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. EMT: ANSI C80.3.

D. FMC: Zinc-coated steel.

E. LFMC: Flexible steel conduit with PVC jacket.

F. 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. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
   2. Fittings for EMT: Steel compression type.

G. 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.

2.2 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. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

A. 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.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

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: Screw-cover type.

E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
   2. EGS/Appleton Electric.
   3. Erickson Electrical Equipment Company.
   4. Hoffman.
   5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
   6. O-Z/Gedney; a unit of General Signal.
   7. RACO; a Hubbell Company.
   8. Scott Fetzer Co.; Adalet Division.
   9. Spring City Electrical Manufacturing Company.
   10. Thomas & Betts Corporation.
   11. Walker Systems, Inc.; Wiremold Company (The).
   12. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
   13. Highline Products.
   14. FSR for Audio/Visual system applications.

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. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Wall outlet boxes.

1. For surface or recessed mounted receptacle, data and/or telephone boxes provide 4” square by 2 1/8” deep box unless noted otherwise on the plans.
   a. Surface mounted cast boxes for mechanical and electrical rooms.
   b. Recessed boxes in finished spaces.

F. Nonmetallic Floor Boxes: Nonadjustable, round.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1 cast aluminum with gasketed cover.

I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2.5 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

C. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.6 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: Stainless steel. Include two for each sealing element.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 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 or EMT.
   3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
   6. Application of Handholes and Boxes for Underground Wiring:
      a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
      b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units SCTE 77, Tier 8 structural load rating.
      c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
      a. Loading dock areas from the floor to a distance of 10-ft above the floor.
      b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units from the floor to a distance of 10-ft. above the floor.
      c. Mechanical and electrical rooms from the floor to a distance of 10-ft. above the floor.
   3. Concealed in Ceilings and 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. Raceways for Communications Cable in Spaces Used for Environmental Air: EMT.
   7. Raceways for Concealed General-Purpose Distribution of Optical Fiber or Communications Cable: EMT.
   8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Steel Conduit:
   a. Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. EMT terminations and couplings:
   a. Steel-plated hexagonal compression connectors.
   b. Pot metal, setscrew or indented type fittings are prohibited.

3.2 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. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. 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.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Install raceways above ceilings tight to the floor structure above.
   1. Group feeder and branch circuit raceways together using common trapeze supports wherever feasible.

I. 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.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. 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.

L. 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.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, 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 raceway sealing fittings at the following points:
   1. Seal raceways where they pass from warm to cold locations to prevent condensation from forming on the inside or exterior surfaces of the raceways:
      a. Boundaries of refrigerated spaces.
      b. From exterior non-conditioned spaces to conditioned spaces.
   2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
   1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
      c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.
      d. Attics: 135 deg F temperature change.
   2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
   3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC in damp or wet locations not subject to severe physical damage.

P. 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.

Q. Junction and pull box minimum size:
   1. Recessed locations.
      a. 4” square x 2 1/8” deep.
      b. Single gang plaster/mud ring.
   2. Accessible locations.
      a. 4” square x 2 1/8” deep.
      b. For pull boxes, larger sizes may be required to meet the NEC requirements for number of conduits and orientation of conduits to the pull box.

R. Device box minimum size:

1. Single receptacle or single wall switch.
   a. 4" square x 2 1/8" deep with single gang plaster/mud ring.
2. Multiple receptacles or wall switches (two devices or switches).
   a. 4" square x 2 1/8" deep with double device plaster/mud ring.
3. Multiple receptacles or wall switches (more than two devices or switches).
   a. Gangable boxes x 2 1/8" deep with appropriately sized plaster/mud ring.

S. All enclosures containing electrical devices shall be UL or third party labeled as an assembly and shall display the appropriate label on the enclosure. This shall include HVAC control enclosures whether manufactured for a specific purpose or fabricated in the field from UL or third party listed materials and/or electrical devices. The electrical devices shall include, but are not be limited to, the following:
   1. Control relays
   2. Control transformers
   3. Fuses
   4. Disconnect switches
   5. Motor starting equipment
   6. Contactors
   7. Terminal/barrier strips

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of 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. 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.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials.

J. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 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.

1.3 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.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

1.5 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

2.1 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.

2.2 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.

2.3 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.

2.4 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. Dimension in first subparagraph below is clear space prescribed in NFPA 70 (2002 Edition), Table 110-26(A)(1), for equipment with nominal voltage to ground of 151 to 600 V, and with grounded parts, including concrete, brick, or tile walls, opposite the equipment. Additional clear space is required at this voltage if there are unguarded exposed live parts on both sides of the workspace. Retain below and revise to suit Project conditions or requirements of authorities having jurisdiction, or indicate varying clearance requirements on Drawings.
   3. Workspace Clearance Warning(less than 150V to ground): "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
   4. Workspace Clearance Warning(150V to ground or greater): "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 42 INCHES."

2.5 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.

2.6 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. Blue surface with white core for 120/208 volt equipment.
   2. Black surface with white core for 277/480 volt equipment.

C. Provide a Brady Model BBP35 Industrial Label maker (available thru Grainger, Cat. #40AW42) and all tape required as listed below. The equipment shall be turned over to Design + Construction project manager at end of job. Labels made for this project shall be made with the tape provided; balance of tape and ribbons shall be turned over. Obtain written receipt at turnover and include copy with contract closeout documents. Provide a list of all labels and exact wording to review with hospital and get approval on prior to making labels. Schedule meeting 3 weeks in advance to review labels with hospital. All labels shall be installed by the contractor.

D. Provide brady tape for above label maker in lengths of 400’ x 4”, 400’ x 2-1/4”, 400’ x 1-1/8” and 400’ x 1/2" in the following colors:
   1. Yellow
   2. Orange
   3. Green
   4. Black
   5. Red
   6. White

E. Provide ribbons for the above label maker in the following colors:
   1. Black
   2. White – Equipment/System Identification
   3. Red

2.7 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: Two 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: Two 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

3.1 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. Fire Alarm System: Red.
2. Fire-Suppression Supervisory and Control System: Red and yellow.
3. Combined Fire Alarm and Security System: Red and blue.
4. Security System: Blue and yellow.
5. Mechanical and Electrical Supervisory System: Green and blue.
6. Telecommunication System: Green and yellow.
7. Control Wiring: Green and red.

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. 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.

I. 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. Disconnect switches.
      b. Motor starters.
      c. Monitoring and control equipment.
      d. Frequency converters.

3.2 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. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

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. Color system Identification for Raceways:

   1. System requiring color EMT raceways or color-coding paint bands for IMC and GRC:
      a. Power Circuits
         1) Normal Power

b. Secondary Systems
1) HVAC Controls.

2. EMT conduit shall be manufactured in colors matching the requirements of this specification.

I. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

J. 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 exceeds 16 inches overall.

K. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

L. 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 section 2.6 F 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. The Contractor shall 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.

M. 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.

END OF SECTION 260553

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

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. This Section includes the following individually mounted, enclosed switches and circuit breakers:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Individually mounted Molded-case circuit breakers.
   4. Enclosures.

1.3 DEFINITIONS

A. GD: General duty.

B. GFCI: Ground-fault circuit interrupter.

C. HD: Heavy duty.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.4 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. UL listing for series rating of installed devices.
   5. 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 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. 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.

1.5 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.

1.6 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 Fand not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.7 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 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: NEMA KS 1 (NEMA 3R for exterior applications), 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: NEMA KS 1 (NEMA 3R for exterior applications), 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.

2.3 FUSED POWER CIRCUIT DEVICES

2.4 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Moeller Electric Corporation.
4. Siemens Energy & Automation, Inc.
5. 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: For breakers less than 100A if coordinated with upstream device, otherwise use electronic trip. 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. 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.

3. GFCI Circuit Breakers: Single- and two-pole configurations with **5** or 3**0**-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 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: 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**] [**75**] percent of rated voltage.
6. 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.
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.5 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Outdoor Locations: NEMA 250, Type 4x, SS.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping

PART 3 - EXECUTION

3.1 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.

3.2 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.

3.3 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."

3.4 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. 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

3.5 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges. Verify settings with Engineer of record.

3.6 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 262816

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes variable frequency controllers.

B. Interface: Provide microprocessor based communication card with BACNET, LonWorks protocols.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:
   1. IEEE 519 - Recommended Practice for harmonic control.

1.3 SUBMITTALS

A. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

B. Product Data: Submit catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

C. Compliance to IEEE 519 – Harmonic analysis for particular jobsite including total voltage harmonic distortion and total current distortion
   1. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE std 519 by not exceeding 5% at the feed breaker.
   2. The Drive manufacturer shall provide calculations, specific to this installation, showing total harmonic current distortion (TDD), at the Point of Common Coupling (PCC), is less than required. Input line filters shall be sized and provided as required by the Drive manufacturer to ensure compliance with IEEE standard 519-1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems. The acceptance of this calculation must be completed prior to Drive installation.
   3. Prior to installation, the Drive Manufacturer shall provide the estimated total harmonic distortion (THD) caused by the Drive. The results shall be based on a computer aided circuit simulation of the total actual system, with information obtained from the power provided and the user.
   4. If the total current distortion (TDD), at the Point of Common Coupling (PCC), exceeds required levels, the Drive manufacturer is to provide the additional equipment required to reduce the current TDD to an acceptable level. This is the responsibility of the

contractor to send all panel schedules and locations to Drive manufacturer for pricing prior to the bid.

D. Test Reports: Indicate field test and inspection procedures and test results.

E. Manufacturer's Field Reports: Indicate start-up inspection findings.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit instructions complying with NEMA ICS 7.1. Include procedures for starting and operating controllers, and describe operating limits possibly resulting in hazardous or unsafe conditions. Include routine preventive maintenance schedule.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided. Handle carefully to avoid damage to components, enclosure, and finish.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Service conditions during and after installation of variable frequency controllers at ambient temperatures between 0 degrees to 50 degrees centigrade at altitude not exceeding 500 ft with relative humidity less than 95%.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY CONTROLLER

A. Manufacturer:
   1. Yaskowa.
   2. ABB.
   3. Danfoss
   4. Sq. D.
   5. Product Description: low harmonic, enclosed variable frequency controller suitable for operating indicated loads with 6-pulse input.

B. Ratings:
   1. Rated Input Voltage: 480 volts, three phase, 60 Hertz.
   2. Motor Nameplate Voltage: 460 volts, three phase, 60 Hertz.

3. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.
4. Operating Ambient: 0 degrees C to 50 degrees C.
5. Minimum Efficiency at Full Load: 98%.

C. Design Features:
1. Employ microprocessor-based inverter logic isolated from power circuits.
2. Employ pulse-width-modulated inverter system.
3. Design for ability to operate controller with motor disconnected from output.
4. Design to attempt five automatic restarts following fault condition before locking out and requiring manual restart.
5. Employ line reactor on line side of drive or active front end low harmonic units.

D. Indicators and Manual Controls:
1. Input Signal: 4 - 20 mA DC.
2. Display: Furnish integral digital display to indicate output voltage, output frequency, and output current.
3. Status Indicators: Separate indicators for overcurrent, overvoltage, ground fault, overtemperature, and input power ON.
4. Volts Per Hertz Adjustment: 0-100 percent.
5. Current Limit Adjustment: 25-136 percent of rated, motor load.
6. Acceleration Rate Adjustment: 0.5 - 30 seconds.
7. Deceleration Rate Adjustment: 1 - 30 seconds.
8. HAND-OFF-AUTOMATIC selector switch and manual speed control.
9. Control Power Source: Integral control transformer.

E. Safeties and Interlocks:
1. Includes undervoltage release.
2. Door Interlocks: Mechanical means to prevent opening of equipment with power connected, or to disconnect power when door is opened; include means for defeating interlock by qualified persons.
3. Safety Interlocks: Terminals for remote contact to inhibit starting under both manual and automatic mode.
4. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.
5. Manual Bypass: Includes barriered contactor, motor running overload protection, and short circuit protection for full voltage, non-reversing operation of motor. Includes isolation switch to allow maintenance of inverter during bypass operation.
6. Emergency Stop: Use dynamic brakes for emergency stop function.
7. Disconnecting Means: Integral on line side of each controller.

F. Fabrication:
1. Wiring Terminations: Match conductor materials and sizes as indicated on Drawings.
2. Enclosure: NEMA 3R/1, suitable for equipment application in places accessible only to qualified personnel.
3. Finish: Manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify building environment is maintained within service conditions required by manufacturer.

3.2 EXISTING WORK

A. Disconnect and remove abandoned controllers.

B. Clean and repair existing controllers to remain or to be reinstalled.

3.3 INSTALLATION

A. Install in accordance with NEMA ICS 7.1.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Install fuses in fusible switches.

D. Select and install overload heater elements in motor controllers to match installed motor characteristics.

E. Install engraved plastic nameplates in accordance with Section 26 0553.

F. Neatly type label inside controller door identifying motor served nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place label in clear plastic holder.

G. Ground and bond controller.

3.4 MANUFACTURER'S FIELD SERVICES

A. Prepare and startup variable frequency controller.

3.5 TESTING

A. Perform inspections and tests listed in NETA ATS, by a NETA certified agent. Provide written reports.

3.6 DEMONSTRATION AND TRAINING

A. Furnish 4 hours of instruction each for two persons, to be conducted at project site with manufacturer's representative.

END OF SECTION 262923