



## **MIDDLE SCHOOL HVAC EQUIPMENT REPLACEMENT AND UPGRADES**

Grove City Area School District  
511 Highland Avenue, Grove City, PA 16127

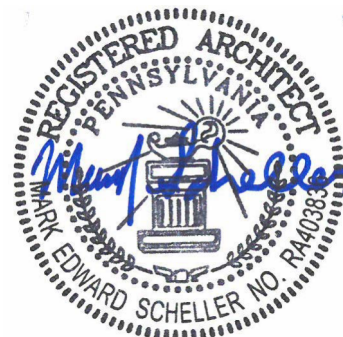
DRAW Project No.: 25-S43-01

**OWNER:**

**GROVE CITY AREA SCHOOL DISTRICT**  
511 Highland Avenue  
Grove City, PA 16127

**ARCHITECT:**

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## TABLE OF CONTENTS

### **VOLUME 1**

#### **INTRODUCTORY INFORMATION**

00 0001	Project Title Page
00 0110	Table of Contents

#### **BIDDING REQUIREMENTS**

00 1113	Advertisement to Bids
00 2113	Instructions to Bidders
00 2116	Pre-Bid RFI Form
00 2600	Pre-Bid Substitution Request
00 3100	Available Project Information
00 4116G	General Construction Bid Form
00 4116H	HVAC Construction Bid Form
00 4116P	Plumbing Construction Bid Form
00 4116E	Electrical Construction Bid Form
00 4512	Contractor Qualification
00 4519	Non-Collusion Affidavit

#### **CONTRACTING REQUIREMENTS**

00 5213	Agreement
00 6100	Bond Forms
00 7213	General Conditions
00 7346	Wage Determination Schedule
00 7393	Covenant to Indemnify

#### **SPECIFICATIONS**

##### **Division 01 - General Requirements**

01 1000	Summary
01 1200	Multiple Contract Summary
01 2200	Unit Prices
01 2300	Alternates
01 2500	Substitution Procedures
01 2926	Modification and Payment Procedures
01 3100	Project Management and Coordination
01 3200	Construction Progress Documentation
01 3233	Photographic Documentation
01 3300	Submittal Procedures
01 3516	Alteration Project Procedures
01 4000	Quality Requirements
01 4100	Regulatory Requirements
01 4200	References
01 5000	Temporary Facilities and Controls
01 6000	Product Requirements
01 7300	Execution
01 7700	Closeout Procedures

01 7823	Operation and Maintenance Data
01 7839	Project Record Documents
01 7900	Demonstration and Training
01 9113	General Commissioning Requirements

## **VOLUME 2**

### **Division 02 - Existing Conditions**

02 4119	Selective Demolition
---------	----------------------

### **Division 03 - Concrete**

### **Division 04 - Masonry**

### **Division 05 - Metals**

### **Division 06 - Wood, Plastics, and Composites**

### **Division 07 - Thermal and Moisture Protection**

07 8413	Penetration Firestopping
07 8446	Fire-Resistive Joint Systems
07 9213	Joint Sealants

### **Division 08 - Openings**

08 3113	Access Doors and Frames
---------	-------------------------

### **Division 09 - Finishes**

09 2216	Non-Structural Metal Framing
09 2900	Interior Gypsum Board
09 5113	Acoustical Panel Ceilings
09 9123	Painting

### **Division 10 - Specialties**

### **Division 11 - Equipment**

### **Division 12 - Furnishings**

### **Division 13 - Special Construction (Not Used)**

### **Division 14 - Conveying Equipment (Not Used)**

### **Division 21 - Fire Suppression (Not Used)**

## **VOLUME 2**

### **Division 22 - Plumbing**

22 0500	Common Work Results for Plumbing
22 0529	Hangers and Supports for Plumbing Piping and Equipment
22 0553	Identification for Plumbing Piping and Equipment

22 1616 Facility Natural Gas Piping

### **Division 23 - Heating Ventilating and Air Conditioning**

23 0500 Common Work Results for HVAC  
23 0510 Basic Electrical Requirements for HVAC Equipment  
23 0511 Enclosed Motor Controllers for HVAC Equipment  
23 0512 Variable Frequency Motor Controllers for HVAC Equipment  
23 0513 Common Motor Requirements for HVAC Equipment  
23 0519 Meters and Gauges for HVAC Piping  
23 0523 General-Duty Valves for HVAC Piping  
23 0529 Hangers and Supports for HVAC Piping and Equipment  
23 0548.13 Vibration Controls for HVAC Piping and Equipment  
23 0553 Identification for HVAC Piping and Equipment  
23 0593 Testing, Adjusting, and Balancing for HVAC  
23 0713 HVAC Duct Insulation  
23 0716 HVAC Equipment Insulation  
23 0719 HVAC Piping Insulation  
23 0801 Commissioning of HVAC  
23 0900 Instrumentation and Control for HVAC  
23 0993 Sequence of Operation for HVAC Controls  
23 2113 Hydronic Piping  
23 2123 Hydronic Pumps  
23 2513 Water Treatment for Closed Loop Hydronic System  
23 3113 Metal Ducts  
23 3300 Air Duct Accessories  
23 7413 Packaged Rooftop Air Conditioning Units

### **Division 26 - Electrical**

26 0100 Basic Electrical Requirements  
26 0519 Low Voltage Electrical Power Conductors and Cables  
26 0526 Grounding and Bonding for Electrical Systems  
26 0529 Hangers and Supports for Electrical Systems  
26 0533 Raceways and Boxes for Electrical Systems  
26 0544 Sleeves and Seals for Electrical Systems  
26 0553 Identification for Electrical Systems  
26 1900 Addressable Fire Alarm System  
26 2726 Wiring Devices  
26 2813 Fuses  
26 2816 Enclosed Switches and Circuit Breakers

### **Division 27 - Communications (Not Used)**

### **Division 28 - Electronic Safety and Security (Not Used)**

### **Division 31 - Earthwork (Not Used)**

### **Division 32 - Exterior Improvements (Not Used)**

### **Division 33 - Utilities (Not Used)**

**END OF DOCUMENT**



## PLUMBING INDEX

SECTION	DESCRIPTION	PAGE NO.
22 0500	General Provisions and Common Work Results for Plumbing	1 - 26
22 0529	Hangers and Supports for Plumbing Piping and Equipment	1 - 7
22 0553	Identification for Plumbing Piping and Equipment	1 - 3
22 1616	Facility Natural Gas Piping	1 - 13

## **SECTION 22 0500 - GENERAL PROVISIONS AND COMMON WORK RESULTS FOR PLUMBING**

### **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 and other sections of Division 22.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Piping materials and installation instructions common to most piping systems.
  - 2. Transition fittings.
  - 3. Dielectric fittings.
  - 4. Mechanical sleeve seals.
  - 5. Sleeves.
  - 6. Escutcheons.
  - 7. Plumbing demolition.
  - 8. Cleaning up/removal of debris.
  - 9. Equipment installation requirements common to equipment sections.
  - 10. Operating and maintenance data and owner instruction.
  - 11. Flashing.
  - 12. Painting and finishing.
  - 13. Supports and anchorages.
  - 14. Materials prohibited.
  - 15. Certification.
  - 16. Guarantee of Work.
  - 17. Final plumbing connections.

#### **1.3 DEFINITIONS**

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

- F. The following are industry abbreviations for plastic materials:
1. ABS: Acrylonitrile-butadiene-styrene plastic.
  2. CPVC: Chlorinated polyvinyl chloride plastic.
  3. PE: Polyethylene plastic.
  4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
  2. NBR: Acrylonitrile-butadiene rubber.
- H. The term "as indicated" means as shown on drawings by notes, graphics or schedules, or written into other portions of contract documents. Terms such as "shown", "noted", "scheduled" and "specified" have same meaning as "indicated", and are used to assist the reader in locating particular information.
- I. It is the intention of these Contract Documents to call for finished work, tested and ready for operation.
1. The word "PROVIDE" shall mean "furnish and install, complete and ready for use" all items noted on the drawings and/or indicated in the Specifications.
  2. The word "FURNISH" shall mean "supply and deliver to the job site" all items noted on the drawings and/or indicated in the Specifications. The items will be installed by the Owner or another contractor.
  3. The word "INSTALL" shall mean "install complete and ready for use" all items furnished by the Owner or another contractor which are noted on the drawings and/or indicated in the Specifications to be installed by the Plumbing Contractor.
  4. The word "RELOCATE" shall mean "move from the existing location to the new location installed complete and ready for use" all items noted on the drawings and/or indicated in the Specifications.
- J. References made to Plumbing Contractor throughout Division 22 is intended to refer to the contractor or subcontractor who will furnish and install Plumbing materials and equipment.

#### **1.4 QUALIFICATIONS FOR BIDDERS**

- A. The Plumbing Contractor shall be experienced in work similar to that indicated for this Project and shall have a record of successful in-service performance.
- B. Upon request, the Plumbing Contractor shall provide a listing of similar jobs with references.
- C. Before submitting bid, the Plumbing Contractor shall visit the site and examine existing conditions on which his work is in any way dependent. The Plumbing Contractor shall immediately report to the Architect any condition which might prevent him from installing his equipment in the manner intended.

#### **1.5 BID SUBMISSION REQUIREMENTS**

- A. The Plumbing Contractor shall submit his bid, including the Base Bid and all Alternate Bids, in accordance with the General Provisions of the Contract, including General, Supplementary and Special Conditions.
- B. Only one manufacturer shall be listed for each equipment item.



## **1.6 LAWS, CODES, AND REGULATIONS**

- A. All work shall be installed in accordance with accepted trade standards or practices. Accepted trade standards or practices shall be documented and shall be based on sound engineering design principles. Accepted trade standards or practices must include a statement indicating that the specific application in question is included within its scope. Accepted trade standards and practices must be documented through an engineering society or trade organization.
- B. Failure to follow laws, codes, public regulations and accepted trade standards or practices will result in rejection of the work. All rejected work shall be removed and replaced at no additional cost to the Owner.
- C. Nothing contained in these Specifications or shown on the Drawings shall be construed to be in conflict with state or local codes, ordinances or regulations governing the installation of the work specified herein. Should any change in the Drawings and/or Specifications be required in order to conform to the applicable codes, ordinances, regulations or laws, the Plumbing Contractor shall notify the engineer immediately upon discovery of the violation.
- D. Products furnished for this project shall be "LEAD FREE" as required by Federal legislation passed on January 4, 2011. This entails the wetted surfaces of plumbing fixtures, equipment, valves, etc. described in each section to have a weighted-average lead content of no more than 0.25% when used in applications intended to convey or dispense water for human consumption through drinking or cooking.

## **1.7 REGULATORY REQUIREMENTS**

- A. Conform to applicable Building Codes.
  - 1. Commonwealth of Pennsylvania, Department of Labor and Industry.
    - a. Fire and Panic Regulations.
    - b. Regulations Governing Boilers and Unfired Pressure Vessels.
    - c. Elevator Law.
- B. Plumbing: Conform to NFPA 13, 14, and 20.
- C. Plumbing: Conform to the 2018 International Plumbing Code

## **1.8 PERMITS, FEES, AND NOTICES**

- A. The Plumbing Contractor shall give all requisite notices, obtain and pay all deposits and fees necessary for the installation, tests connections to the utility company service lines, street openings, repairs and inspection of all work provided under this Specification. These tests shall be conducted in the presence of the Architect.

## **1.9 APPLICABLE PUBLICATIONS**

- A. The publications listed in each section form a part of that Section to the extent referenced.
- B. The publication date is the publication in effect as of the bid date, except when a specific publication date is specified.
- C. Obtain copies of referenced standards direct from publication source when needed for proper performance of work, or when required for submittal by Contract Documents.

#### **1.10 SCOPE OF WORK**

- A. The work to be performed consists of the satisfactory completion of all Plumbing work, as indicated in the Contract Documents.
- B. The work to be performed under these specifications shall include providing all labor, materials and equipment necessary to furnish and install, complete, properly and fully, all Plumbing Work as shown on drawings, herein specified and/or necessary thereto, whether or not specified herein in detail, and/or reasonably implied, and leaving the same in satisfactory operating condition. It is the intent of these specifications that a complete and operating system shall be installed and this Contractor shall carefully examine the site, plans, and specifications, and shall include all items necessary to accomplish this purpose.

#### **1.11 SCHEDULING OF WORK**

- A. This project consists of new construction and renovation work. Due to the size, scope and time required to complete this work, it may be necessary to perform the work in phases in order to allow the owner to continue with their business operations with a minimum amount of disruption.
- B. The Contractor shall thoroughly review the plumbing drawings, along with the architectural drawings, for the phasing sequence and shall incorporate into his bid the impact the phasing sequence and the construction schedule has on the Plumbing work in this project.
- C. Initially, upon award of all construction contracts, work shall begin on new construction. Early in this portion of the work, and so as to avoid or minimize disruption to the owner.

#### **1.12 DESCRIPTION OF SYSTEMS**

- A. Without intending to limit or restrict the volume of work required by this Specification and the applicable drawings, the work generally consists of:
  - 1. Extension of existing natural gas system to new HVAC equipment.
  - 2. Cleaning.
  - 3. Painting of piping, supports and hangers.
  - 4. Testing, balancing and adjusting.
  - 5. Cutting and patching for new work in the existing building.
  - 6. Demolition work as required.
  - 7. Operating and maintenance instructions and manuals.
  - 8. Demonstration of successful system operation.

#### **1.13 EQUIPMENT FURNISHED UNDER OTHER CONTRACTS**

- A. Unless otherwise specified or shown on the drawings, this Contractor shall make final plumbing connections to all equipment furnished under General and Electrical Contracts. For HVAC equipment, this Contractor shall provide a capped water outlet within two (2) feet of the HVAC equipment, and the HVAC Contractor shall make and be responsible for the final connections. For HVAC gas fired equipment, this Contractor shall make the final gas connections to the equipment.
- B. Unless otherwise specified or shown on drawings, the equipment furnished under the concurrent contracts will be furnished with their operating controls. This Contractor shall provide valves on water and gas, and unless otherwise shown or specified traps on waste outlets, and shall furnish all labor and materials

required to connect the equipment and make it operative. Unless otherwise shown or specified valves on lines to equipment shall be ball valves.

- C. Equipment furnished under other contracts will be set in place by the Contractor for that equipment. Controlling devices for this equipment will be furnished with the equipment, but were supplied detached, they shall be installed into the plumbing work piping assemblies by the Plumbing Contractor.
- D. This Contractor shall refer to the shop drawings of equipment furnished under other contracts to obtain the locations of connections and arrangements of piping assemblies to which he is required to connect. All the required pipe, fittings, adapters, couplings and other accessories required to make the equipment operative shall be provided by this Contractor.
- E. Products furnished to the site and paid for by the Owner.

#### **1.14 SPACE PRIORITY**

- A. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
  - 1. Gravity flow piping systems.
  - 2. Vent piping systems.
  - 3. Ceiling recessed lighting fixtures.
  - 4. Concealed air terminal units, fans.
  - 5. Air duct systems.
  - 6. Sprinkler systems piping.
  - 7. Forced flow piping systems.
  - 8. Electrical conduit, wiring, control wiring.
- B. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
- C. Change in order of priority is permissible by mutual agreement of all affected trades.
- D. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
- E. The work of a particular trade shall not obstruct access for installation, operation and maintenance of the Work, materials and equipment of another trade.
- F. This Contractor shall verify roughing-in dimensions for all fixtures and equipment prior to his roughing-in for such fixtures and equipment.

#### **1.15 DEMOLITION WORK**

- A. The Plumbing Contractor shall demolish all work as outlined on the drawings.
- B. The Owner shall decide the disposition of all salvaged materials. The Plumbing Contractor shall deliver to the Owner all materials identified to be salvaged.
- C. When demolishing existing equipment, the Plumbing Contractor shall remove all existing piping, supports, hangers, hanger rods, anchor bolts, structural steel, and concrete pads related to the work being removed.

- D. Where demolition of work results in unsightly openings in occupied spaces or jeopardizes the integrity of a fire or smoke barrier, the opening shall be patched in accordance with the paragraph in this section entitled "Cutting Patching, and Finishing".
- E. Where demolition requires the removal of a concrete equipment pad, remove the pad, cut all anchor bolts, dowel pins, and steel bases off flush with the floor so as to eliminate any tripping hazard. Fill any openings, voids, or holes with a fine cement grout or another appropriate floor patching material. Provide surface finish to match adjacent flooring material.

#### **1.16 CUTTING AND PATCHING**

- A. Cutting and patching shall be in accordance with Division 1 Section "Execution".
- B. The Plumbing Contractor shall seal all openings he has utilized in fire-rated floors, ceilings or partitions after his work has been installed. The material used for sealing the openings shall have a fire-rating equal to or greater than the rating of the floor, ceiling or partition material.
- C. The Plumbing Contractor shall be responsible for providing all cutting, patching, and finishing of existing construction which is not specifically shown on the Architectural Drawings and which is required for the proper installation of his equipment and materials which are to be installed in the existing portion of this project. This work shall also be provided when removing existing equipment and materials. All cutting shall be kept to an absolute minimum consistent with the requirements of the project.
- D. Cutting, patching and finishing shall be performed by workmen skilled in this type of work. All patching shall be done utilizing materials of the same quality and texture as the adjacent undisturbed areas. All finishing shall match the undisturbed adjacent areas. Painting of the final finished areas, where general construction work occurs, will be the responsibility of the General Contractor. Painting of the final finished areas, where no general construction work occurs, shall be the responsibility of the Plumbing Contractor. The Plumbing Contractor shall paint entire plane in which damage occurs whether the surface is a wall or a ceiling.
- E. No cutting shall be done which may affect the building structurally or architecturally without first consulting with the General Contractor and then securing the approval of the Architect. Cutting shall be accomplished in such a manner as not to cause damage to the building or leave unsightly surfaces which cannot be concealed by plates, escutcheons or other construction. Where such unsightly conditions are caused, the Plumbing Contractor shall be required, at his own expense, to repair the damaged areas. Note all holes or openings in existing concrete or masonry shall be drilled, core bored or saw cut.
- F. Where present equipment or material is removed and unused openings remain in walls, floors, partitions, etc., the Plumbing Contractor shall properly patch all such openings.

#### **1.17 RECORD DRAWINGS**

- A. Provide in accordance with Division 01 Section PROJECT RECORD DOCUMENTS and as stated below.
- B. The Plumbing Contractor shall:
  - 1. During the construction period, maintain in good order a complete set of blue line plumbing contract drawings. Record the actual Plumbing installation as the work progresses. Include all changes to the contract and to equipment sizes and types. Keep these drawings available at the site at all times for inspection.

2. Take proper caution against the use of superseded drawings. Check all such copies and mark "void". Where drawings have been corrected by memorandum, assume the responsibility for marking all drawings so affected with the changes; such marked drawings shall remain in use until revised drawings are issued.

#### **1.18 INTENT OF DRAWINGS AND SPECIFICATIONS**

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable plumbing systems complete in every respect.
  - B. Any apparatus, appliance, material or work not shown as standard industry practice on drawings, but mentioned in the specifications, or vice versa, shall be provided by the Plumbing Contractor without additional expense to the Owner.
  - C. The drawings are diagrammatic, intending to show general arrangement and location of system components, and are not intended to be rigid in detail.
  - D. Due to the small scale of the drawings, all required offsets and fittings may not be shown but shall be provided at no change in Contract price.
  - E. As many of the small lines required for the complete installation are shown on the drawings as is practicable, but some may have been omitted. The Contractor shall do all such piping that may be required or directed to effect proper connections to all apparatus, equipment, and fixtures in accordance with the manufacturer's detailed drawings and instructions.
  - F. The equipment schedules shown on the drawings list the manufacturer used as the basis of design in the preparation of the Bid Drawings. The equipment specifications list that manufacturer as well as other manufacturers the Engineer, Architect and/or Owner find acceptable from a performance and product quality standpoint. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they have a positive or negative monetary impact on the design shown on the Bid Drawings. In addition, listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether the dimensions of these products will have a negative impact on the space allotted for this equipment. If the Contractor or his Subcontractors decide to use a product or manufacturer that is listed as acceptable in the specifications but is different from the product or manufacturer scheduled on the drawings, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the HVAC system(s) and/or the Plumbing system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, etc., between the scheduled item and the equipment item used.
1. Use of a product or manufacturer not scheduled on the Bid Drawings constitutes a representation that:
    - a. The Plumbing Trade has investigated the proposed product and determined that the product can be installed within the space allotted.
    - b. The Plumbing Trade will coordinate the installation of product used into the work
    - c. The Plumbing Trade will be responsible for making all changes as may be required to make the work complete in all respects; waives all claims for additional costs under his responsibility, which may subsequently become apparent.

## **1.19 SUBMITTALS**

- A. Provide in accordance with Division 01 Section SUBMITTAL PROCEDURES and as stated below.
- B. Submit plans to the Pennsylvania Department of Labor and Industry (L&I) Boiler Division. Install water heaters, fired and unfired pressure vessels in conformance with approved drawings providing all required valves, platforms, ladders, exits and clearances. Submit approved L&I drawings to Architect before construction.
- C. Submit Product Data, shop drawings, and samples in accordance with the General Conditions and Supplementary Conditions, within 60 days of award of contract for every item of material, etc. used.
- D. Designate in the construction schedule, or in a separate coordinated schedule, the dates for submission and the dates that reviewed shop drawings, product data and samples will be needed.
- E. Shop Drawings shall be presented in a clear and thorough manner. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on Contract Drawings.
- F. The following is a list of some important material, equipment and systems that require shop drawing approval, refer to each section of this specification for additional submittal requirements:
  - 1. Section 22 0529: Hangers and Supports for Plumbing Piping and Equipment.
  - 2. Section 22 0553: Identification for Plumbing Piping and Equipment.
  - 3. Section 22 1616: Facility Natural Gas Piping.
- G. All drawings prepared by the Plumbing Contractor, for the Plumbing Contractor's use, shall be submitted for approval. Such drawings include, but are not limited to, pipe fabrication and layout drawings, Plumbing piping and layout drawings, equipment layout drawings, coordination drawings, and drawings of miscellaneous details.
- H. Office samples shall be of sufficient size and quantity to clearly illustrate functional characteristics of the product, with integrally related parts and attachment devices, and full range of color, texture and pattern.
- I. The Plumbing Contractor shall be responsible for reviewing shop drawings, product data and samples prior to submission. The Plumbing Contractor shall clearly mark or highlight the submittal to indicate all pertinent information such as model number, dimensions, capacities, clearances, performance characteristics, etc., and shall delete any data which is not relevant to the work. The Plumbing Contractor shall also determine and verify field measurements, field construction criteria, catalog numbers and similar data, and conformance with specifications.
- J. The Plumbing Contractor shall coordinate each submittal with requirements of the work and of the Contract Documents.
- K. The Plumbing Contractor shall notify the Architect in writing, at time of submission, of any deviations in the submittals from requirements of the Contract Documents.
- L. The Plumbing Contractor shall begin no fabrication or work which requires submittals until return of submittals with Architect approval.
- M. The Plumbing Contractor shall make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the work or in the work of any other Contractor.

- N. Unless required otherwise by the General Conditions or the Supplementary Conditions, the number of submittals required shall be as follows:
1. Shop Drawings: Submit the number of opaque reproductions which the Plumbing Contractor requires, plus three copies, one will be retained by the Architect, one copy will be retained by the Engineer, and one copy will be retained by the Owner.
  2. Product Data: Submit the number of copies which the Plumbing Contractor requires, plus three copies; one copy will be retained by the Architect, one copy will be retained by the Engineer, and one copy will be retained by the Owner.
  3. Samples: Submit the number stated in each specification section.
- O. The Plumbing Contractor shall also include in each submittal the date of submission and the dates of any previous submissions; the project title and number; the names of the Plumbing Contractor, the supplier, and the manufacturer; identification of the product, with the specification section number; identification of revisions on resubmittals; and the Plumbing Contractor's stamp, initialed or signed, certifying to review of submittal, verification of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.
- P. For resubmission requirements, the Plumbing Contractor shall make any corrections or changes in the submittals (i.e., shop drawings, samples or product data) required by the Architect and resubmit until approved.
- Q. The Architect will review submittals with reasonable promptness and in accordance with schedule, affix stamp and initials or signature, and indicate requirements for resubmittal, or approval of submittal, and return submittals to Plumbing Contractor for distribution, or for resubmission.
- R. Submittals for equipment and pumps shall include manufacturer's published performance curves showing flow rate, pressure drop, efficiency, horsepower, NPSH required (for pumps), and operating points.
- S. As soon as practicable, and within 30 days after the date of award of contract, and prior to installation of any equipment or material a completed schedule of equipment and material proposed for installation shall be submitted to the A/E for approval.
- T. All material submitted for approval, excepting special equipment and special adaptation of regular equipment as hereinafter specified and as specifically shown on the drawings, shall be standard printed matter made available by the manufacturer to the public and in effect at the time of opening of bids and shall indicate that the material or equipment is regularly produced and recommended for the service required. In the event any items of material or equipment contained in the schedule fail to comply with the specification requirements, such items may be rejected.
- U. In the event that the contractor fails to submit the required schedule of materials and equipment within the allowed time, the A/E will select a complete line of materials, fixtures, and equipment. The selection made shall be final and binding, and the items shall be furnished and installed by the contractor without any change in contract price or time of completion.
- V. Product data for the following:
1. Transition fittings.
  2. Dielectric fittings.
  3. Mechanical sleeve seals.
  4. Escutcheons.
- W. Welding certificates.

## **1.20 SUBSTITUTIONS AND PRODUCT OPTIONS**

- A. Provide in accordance with Division 01 Section SUBSTITUTION PROCEDURES and as stated below.
- B. It will be the responsibility of this contractor to pay any and all costs associated with any approved substitutions which impact the structure, the electrical system(s), the plumbing system(s) and/or the Plumbing system(s) due to an increase in weight, electrical load, drain requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.
- C. For products specified only by reference standard, select any product meeting that standard. For products specified by naming several products or manufacturers, select any one of the products or manufacturers named, which complies with the drawings and specifications. For products specified by naming one or more products or manufacturers and "or equal", Plumbing Contractor must submit a request as for substitutions for any product or manufacturer not specifically named.
- D. The Architect will consider written requests from the Plumbing Contractor for substitution of products by manufacturers not listed in the Specification for a period up to 10 days prior to the Bid. Within this period, submit a separate request for each product, supported with complete data, with drawings and samples as appropriate and as required under the "submittals" paragraph in this section to include: Comparison of the qualities of the proposed substitution with that specified; changes required in other elements of the work because of the substitution; effect on the construction schedule; cost data comparing the proposed substitution with the product specified; availability of maintenance service, and source of replacement materials.
- E. A request for a substitution constitutes a representation that the Plumbing Contractor has investigated the proposed product and determined that it is equal to or superior in all respects to that specified; can be installed within the space allotted; will provide the same warranties or bonds for the substitution as for the product specified; will coordinate the installation of an accepted substitution into the work, and make such other changes as may be required to make the work complete in all respects; waives all claims for additional costs, under his responsibility, which may subsequently become apparent.
- F. The Plumbing Contractor will compensate the Architect and Engineer on a time and material basis for their costs involved in reviewing a substitution.

## **1.21 OPERATING AND MAINTENANCE DATA AND OWNER INSTRUCTION**

- A. Provide in accordance with Division 01 Section OPERATION AND MAINTENANCE DATA and as stated below.
- B. The manual shall contain as a minimum: models and serial numbers for the equipment; description of the equipment/system and its components; recommended routine, preventative and emergency maintenance; start-up, operating and safety instructions; recommended frequency of inspection; oil type; belt tension adjustment; performance curves, engineering data, and tests; "trouble-shooting guide"; a spare parts list; and names, addresses and telephone numbers for the equipment installer, the maintenance contractor, and the local spare parts source.
- C. Provide complete operating and maintenance information for products specified in:
  - 1. Section 22 0529: Hangers and Supports for Plumbing Piping and Equipment.
  - 2. Section 22 0553: Identification for Plumbing Piping and Equipment.
  - 3. Section 22 1616: Facility Natural Gas Piping.



## **1.22 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 Section QUALITY REQUIREMENTS.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
  - 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.
- D. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

## **1.23 DELIVERY, STORAGE, HANDLING, AND PROTECTION**

- A. Provide in accordance with Division 01 Section PRODUCT REQUIREMENTS and as stated below.
- B. Arrange deliveries of products in accordance with construction schedules. Coordinate to avoid conflict with work and conditions at the site. Deliver products in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.
- C. Immediately on delivery, inspect shipments to assure compliance with requirements of Contract Documents and approved submittals, and those products are properly protected and undamaged.
- D. Provide equipment and personnel to handle products by methods to prevent soiling or damage to products or packaging.
- E. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- F. Store new products in accordance with manufacturer's instructions, with seals and labels intact and legible. Store new products or items being re-used in a manner to prevent damage due to the elements, prevent damage due to construction operations at the site, and allow for ease of inspection.
- G. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.
- H. The Plumbing Contractor, at his own expense, shall make good to the Architect and the Owner's satisfaction any damage to his work incurred by the action of the elements or any other cause due to the neglect on the part of the Plumbing Contractor or his representatives.
- I. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

#### **1.24 PROTECTION OF SERVICES AND EQUIPMENT**

- A. Repair, replace and maintain in service any utilities, facilities or services (underground, aboveground, interior and/or exterior) which are damaged, broken, or otherwise rendered inoperative during the course of construction. The method used in repairing, replacing or maintaining the services shall be approved by the Architect and/or Engineer.
- B. The Plumbing Contractor shall protect all work, materials and equipment during the construction period. All openings must be securely covered, or otherwise protected, in order to prevent injury due to dropped tools, materials or dirt.

#### **1.25 SPECIAL CONDITIONS RELATED TO PLUMBING WORK**

- A. During the course of construction, cap or otherwise seal off, in an approved manner, those portions of the piping system in which work is not being performed, in order to prevent the entry of dirt or dust.
- B. The Plumbing Contractor shall coordinate all utility shut-downs with the Owner.
- C. Install equipment along with control devices and all replaceable fittings with sufficient clearance for operation and maintenance functions.
- D. Do not install piping in transformer vaults or electrical equipment rooms. In accordance with the National Electric Code Article 110-34f, do not install piping adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.
- E. Exposed piping shall be run so as to allow maximum headroom consistent with proper pitch. Piping shall not interfere with any light, opening, door, window or equipment. Headroom in front of openings, doors and windows shall not be less than the top of the opening. Minimum clearance of 1 inch shall be maintained around all piping, valves and fittings.
- F. Outside, underground piping shall have a minimum of 36 inches of earth cover, except provide greater coverage to equal locally recorded frost penetrations.
- G. Lay out the work and establish all heights and grades required for installation.
- H. All material and equipment to be furnished under this contract shall be new and shall conform to the grade, quality and standards specified herein. Items of equipment shall be the latest standard product as advertised in printed catalogues by reputable manufacturers for the purpose intended and shall have replacement parts available.
- I. Equipment shall be installed in strict accordance with the manufacturer's instructions for type and capacity of each piece of equipment. The Plumbing Contractor shall obtain these instructions from the manufacturer and such instructions shall be considered a part of these specifications. Type, capacity, and application of equipment shall be suitable and capable of satisfactory operation for the purpose intended in the plumbing system.
- J. Equipment and materials of the same general type shall be of the same make throughout the work to provide uniform appearance, operation, and maintenance.

- K. It shall be the responsibility of the Contractor to ensure that the items to be furnished fit the space available. He shall make necessary field measurements to ascertain space requirements, including those for connection, and shall furnish and install such sizes and shapes of equipment that the final installation shall suit the true intent and meaning of the drawings and specifications.
- L. Where equipment requiring different arrangement or connections from those shown is approved, it shall be the responsibility of the Contractor to install that equipment to operate properly and in harmony with the intent of drawings and specifications. When directed by the Architect, the Contractor shall submit drawings showing the proposed installation. If the proposed installation is approved, the Contractor shall make all incidental changes in piping, ductwork, supports, insulation, wiring, heaters, panelboards, etc. He shall provide any additional motors, controllers, valves, fittings, and other additional equipment for the proper operation of the system resulting from the selection of that equipment, including all required changes in affected trades. The Contractor shall be responsible for the proper location of roughing-in and in connections by other trades. All changes shall be made at no increase in the Contract Amount or additional cost to the other trades.
- M. Unless otherwise noted on the drawings or in the specifications, concrete pads and bases for heaters, tanks, and other equipment shall be furnished and installed by the Contractor furnishing the equipment requiring such pad or base. The Contractor shall establish sizes and locations of the various concrete bases required and shall provide all necessary anchor bolts, together with the templates for holding these bolts in position. Anchor bolts shall be placed in steel pipe sleeves to allow for adjustment, with suitable plate at bottom end of sleeve to hold the bolt. Each concrete base shall be not less than 4" high, which shall project 3" on all sides beyond the equipment. Special vibration isolation foundations that are required are specified with the equipment supported.
- N. The Contractor shall support, plumb, rigid and true to line, all work and equipment furnished under each section. The Contractor shall study thoroughly all general, structural, mechanical, and electrical drawings, shop drawings, and catalog data to determine how equipment, fixtures, piping, conduit, ductwork, etc. are to be supported, mounted, or suspended and shall provide extra steel bolts, inserts, pipe standards, brackets and accessories for proper support, whether or not shown on the drawings. When directed, the Contractor shall submit prints showing supports for approval.
- O. Provide safety guards for all pulleys, belt-drives and rotating equipment. Safety requirements of the Pennsylvania Department of Labor and Industry and OSHA shall be met.

## **1.26 COORDINATION**

- A. Sequence of Work
  - 1. Provide in accordance with Division 01 Section SUMMARY.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

- E. This Plumbing Contractor must cooperate completely and coordinate work with the General Trade and other trades providing equipment under this division and other divisions of the specifications.
- F. Interference drawings shall be prepared as a combined effort of all trades. Each trade shall proceed with their own set of drawings on electronic backgrounds in AutoCAD Format prepared by the Mechanical Contractor. The Mechanical Contractor shall start their drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.
- G. After the Mechanical Contractor has finished, it shall forward one print along with an electronic file to the Plumbing trade that in turn will show and coordinate the plumbing work on the combined plans with the other trades. After the Plumbing trade has finished, it shall forward one print along with an electronic file to the Electrical trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades. After the Electrical trade has finished, it shall forward one print along with an electronic file to the Plumbing trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades
- H. Interference plans and elevations shall show in detail the location of the following items which require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the paragraph entitled "Space Priority".
  - 1. In addition, show mechanical and electrical work in equipment rooms.
  - 2. On the interference drawings, show all electrical conduits which are 1-1/2" and larger.
- I. Reproducible copies along with electronic file of the finished interference drawings shall be submitted to the Architect for record and approval before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
- J. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.

## **1.27 DEMONSTRATION AND TRAINING**

- A. Provide in accordance with Division 01 Section DEMONSTRATION AND TRAINING and as stated below.
- B. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

## **2.2 PIPE, TUBE, AND FITTINGS**

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory threaded pipe and pipe fittings.

## **2.3 JOINING MATERIALS**

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. 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.
  - 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BA91, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
  - 1. ABS Piping: ASTM D 2235.
  - 2. CPVC Piping: ASTM F 493.
  - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
  - 4. PVC to ABS Piping Transition: ASTM D 3138.
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

## **2.4 TRANSITION FITTINGS**

- A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
  - 1. Manufacturers:
    - a. Cascade Waterworks Mfg. Company
    - b. Dresser Industries, Inc.; DMD Division

- c. Ford Meter Box Company, Inc. (The); Pipe Products Division
  - d. JCM Industries
  - e. Smith-Blair, Inc.
  - f. Viking Johnson
- 2. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.
- 3. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.
- 4. Aboveground Pressure Piping: Pipe fitting.
- B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
  - 1. Manufacturers:
    - a. Eslon Thermoplastics
- C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
  - 1. Manufacturers:
    - a. Thompson Plastics, Inc.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
  - 1. Manufacturers:
    - a. Nibco, Inc.
    - b. Nibco, Inc.; Chemtrol Division
- E. Flexible Transition Couplings for Underground Non-pressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
  - 1. Manufacturers:
    - a. Cascade Waterworks Mfg. Company
    - b. Fernco, Inc.
    - c. Mission Rubber Company
    - d. Plastic Oddities, Inc.

## 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: Factory fabricated, union assembly, for 250-psig minimum working pressure at 180°F.

1. Manufacturers:

- a. Capitol Manufacturing Company
- b. Central Plastics Company
- c. Eclipse, Inc.
- d. Epco Sales, Inc.
- e. Hart Industries, International, Inc.
- f. Watts Industries, Inc.; Water Products Division
- g. Zurn Industries, Inc.; Wilkins Division

D. Dielectric Flanges: Factory fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

- a. Capitol Manufacturing Company
- b. Central Plastics Company
- c. Epco Sales, Inc.
- d. Watts Industries, Inc.; Water Products Division

E. Dielectric Flange Kits: 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.

1. Manufacturers:

- a. Advance Products & Systems, Inc.
- b. Calpico, Inc.
- c. Central Plastics Company
- d. Pipeline Seal and Insulator, Inc.

2. 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: Galvanized steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.

1. Manufacturers:

- a. Calpico, Inc.
- b. Lochinvar Corporation

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225°F.

1. Manufacturers:

- a. Perfection Corporation
- b. Precision Plumbing Products, Inc.
- c. Sioux Chief Manufacturing Co., Inc.
- d. Victaulic Company of America

## 2.6 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
  - 1. Manufacturers:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Company
    - d. Pipeline Seal and Insulator, Inc.
  - 2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 3. Pressure Plates: Carbon steel or Stainless steel. Include two for each sealing element.
  - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## 2.7 SLEEVES

- A. Galvanized Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
  - 1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.
- H. Sleeves for Pipes through Non-Fire Rated Walls and Floors: Form with galvanized steel.
- I. Sleeves for Pipes through Exterior Masonry and Concrete Walls and Slabs below Grade: Form with schedule 40 steel pipe with water stops.
- J. Sleeves for Pipes through Masonry and Concrete Walls and Slabs above Grade: Form with Schedule 40 steel pipe.
- K. Sleeves for Pipe through Drywall and Plaster Partitions: Form with galvanized steel.
- L. Provide Link-Seal by Thunderline Corporation for below grade piping penetrations through exterior walls and slabs.



## **2.8 ESCUTCHEONS**

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome plated finish.
- C. One-Piece, Cast brass Type: With set screw.
  - 1. Finish: Polished chrome plated and rough brass.
- D. Split-Casting, Cast brass Type: With concealed hinge and set screw.
  - 1. Finish: Polished chrome plated and rough brass.
- E. One-Piece, Stamped steel Type: With set screw or spring clips and chrome plated finish.
- F. Split-Plate, Stamped steel Type: With concealed hinge, set screw or spring clips, and chrome plated finish.
- G. One-Piece, Floor plate Type: Cast iron floor plate.
- H. Split-Casting, Floor plate Type: Cast brass with concealed hinge and set screw.

## **PART 3 - EXECUTION**

### **3.1 PLUMBING DEMOLITION**

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed:
  - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
  - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
  - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
  - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
  - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.
- D. When demolishing existing equipment, the Plumbing Contractor shall remove all existing piping, insulation, supports, hangers, hanger rods, anchor bolts, structural steel, and concrete pads related to the work being removed. When demolishing piping branch runouts, remove the entire branch which is accessible above lay-in ceilings or accessible during the construction period back to the main, unless otherwise noted. When demolishing equipment and fixtures and the branch runouts are inaccessible, cap, seal, and abandon the branch runouts in an approved manner.

- E. Where demolition of work results in unsightly openings in occupied spaces or jeopardizes the integrity of a fire or smoke barrier, the opening shall be patched in accordance with Division 1.
- F. Where demolition requires the removal of a concrete equipment pad, remove the pad, cut all anchor bolts, dowel pins, and steel bases off flush with the floor so as to eliminate any tripping hazard. Fill any openings, voids, or holes with a fine cement grout or another appropriate floor patching material. Provide surface finish to match adjacent flooring material.

### **3.2 CLEANING UP/REMOVAL OF DEBRIS**

- A. This Contractor shall periodically, and at such times as directed by the Professional, remove from the premises all trash and debris caused by the performance of his work. At the completion of the work, all parts of the plumbing installation shall be thoroughly cleaned by this Contractor. All piping, flush valves, fixtures, trim, strainers, etc., shall be cleaned of all grease, dirt and metal cuttings. All plumbing fixtures shall be cleaned to restore to their original condition.
- B. Any damage to the building finishes or furnishings due to the failure of this Contractor to afford proper protection during the execution of his work, shall be restored in a manner satisfactory to the Architect/Owner.

### **3.3 PIPING SYSTEMS - COMMON REQUIREMENTS**

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. 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 Coordination Drawings.
- 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 to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Water piping shall be graded in such a manner as to be completely drain the entire system and to permit air relief of hot water piping systems.
- L. Select system components with pressure rating equal to or greater than system operating pressure.

M. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
- b. Chrome plated Piping: One-piece, cast brass type with polished chrome plated finish.
- c. Insulated Piping: One-piece, stamped steel type with spring clips.
- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast brass type with polished chrome plated finish.
- e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast brass type with polished chrome plated finish.
- f. Bare Piping in Unfinished Service Spaces: One-piece, cast brass type with polished chrome plated or rough-brass finish.
- g. Bare Piping in Equipment Rooms: One-piece, cast brass type.
- h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor plate type.

2. Existing Piping - use the following:

- a. Chrome plated Piping: Split-casting, cast brass type with chrome plated finish.
- b. Insulated Piping: Split-plate, stamped steel type with concealed hinge and spring clips.
- c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast brass type with chrome plated finish.
- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel type with concealed hinge and spring clips.
- e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast brass type with chrome plated finish.
- f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel type with concealed hinge and set screw.
- g. Bare Piping in Unfinished Service Spaces: Split-casting, cast brass type with polished chrome plated or rough-brass finish.
- h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel type with concealed or exposed-rivet hinge and set screw or spring clips.
- i. Bare Piping in Equipment Rooms: Split-casting, cast brass type.
- j. Bare Piping in Equipment Rooms: Split-plate, stamped steel type with set screw or spring clips.
- k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor plate type.

N. Sleeves are not required for core-drilled holes.

O. Permanent sleeves are not required for holes formed by removable PE sleeves.

P. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

Q. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

- a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
  - a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
  - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
  - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
    - 1) Seal space outside of sleeve fittings with grout.
4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- R. Aboveground, Exterior Wall Pipe 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.
  1. Install steel pipe for sleeves smaller than 6 inches in diameter.
  2. Install cast iron "wall pipes" for sleeves 6 inches and larger in diameter.
  3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- S. Underground, Exterior-Wall Pipe Penetrations: Install cast iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- T. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- U. Verify final equipment locations for roughing-in.
- V. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- W. Exposed piping in finished spaces shall be chrome-plated

### 3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 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.
  - 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. 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.
- H. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- J. Plastic piping solvent-cement 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
  - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
  - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
  - 5. PVC Non-pressure Piping: Join according to ASTM D 2855.
  - 6. PVC to ABS Non-pressure Transition Fittings: Join according to ASTM D 3138 Appendix.

### **3.5 PIPING CONNECTIONS**

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
  - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
  - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

### **3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS**

- A. Provide in accordance with Division 01 Section EXECUTION and as stated below.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment to allow right of way for piping installed at required slope.

### **3.7 STARTING OF PLUMBING SYSTEMS AND EQUIPMENT**

- A. Provide material and labor required to perform start-up of each respective item of equipment and system prior to beginning of test, adjust and balance procedures. Refer to the section in Division 22 in which the system or equipment item is specified for specific start-up requirements for that system or equipment item.

### **3.8 FLASHING**

- A. Openings in roofs for extended soil and vent pipe shall be flashed by the General Contractor. Refer to detail on Architectural drawings.

### **3.9 PAINTING**

- A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

### **3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES**

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

### **3.11 ERECTION OF WOOD SUPPORTS AND ANCHORAGES**

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

### **3.12 MATERIALS PROHIBITED**

- A. Absolutely no materials, equipment, etc., containing asbestos and/or lead shall be installed on this construction project. No deviations will be entertained or accepted.

### **3.13 FINAL CLEANING**

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES.

### **3.14 CERTIFICATION**

- A. After a final site observation has been performed by the engineer, the contractor shall provide the Owner with a letter certifying that he did not install any asbestos-containing and/or lead containing materials on this project a result of his construction work. In addition, the contractor shall provide the owner with a letter from each of his sub-contractors certifying the same.

### **3.15 GUARANTEE OF WORK**

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES and as stated below.
- B. Where applicable, furnish manufacturer's written warranty for materials and equipment.
- C. This Plumbing Contractor shall furnish a written warranty stating that all work shall be free from defects of equipment, material for workmanship for a period of one year from date of final acceptance and all defects developing during that period shall be made good without cost to the Owner.
- D. This Plumbing Contractor shall service the installation for one year from date of final acceptance. This shall include all emergency service and adjustment, with the exception of the oiling of motors and cleaning of filters and screens.

### **3.16 FINAL PLUMBING CONNECTIONS**

- A. Provide rough-in and final connection of all Plumbing services needed for equipment provided by the Owner or by other trades. Shop Drawings will be furnished by those providing the equipment. These Drawings shall be checked by the trade responsible for rough-in and final connections before submission to the Architect for approval. The work shall be done in accordance with the approved Shop Drawings.
- B. In general, connection and termination points are given in the Contract Documents. Where not given or where conflicts occur, refer the question to the Architect for a binding decision.

**END OF SECTION 22 0500**



## **SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**

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

#### **1.3 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."

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

#### **1.5 SUBMITTALS**

- A. Product data for the following:
  - 1. Steel pipe hangers and supports.
  - 2. Thermal hanger shield inserts.
  - 3. Powder actuated fastener systems.
  - 4. Pipe positioning systems.
- B. Welding certificates.

## **1.6 QUALITY ASSURANCED**

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

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

### **2.2 STEEL PIPE HANGERS AND SUPPORTS**

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
  - 1. AAA Technology & Specialties Co., Inc.
  - 2. Bergen-Power Pipe Supports
  - 3. B-Line Systems, Inc.; a division of Cooper Industries
  - 4. ERICO/Michigan Hanger Company
  - 5. Globe Pipe Hanger Products, Inc.
  - 6. Grinnell Corporation
  - 7. National Pipe Hanger Corporation
  - 8. PHD Manufacturing, Inc.
  - 9. PHS Industries, Inc.
  - 10. Piping Technology & Products, Inc.
- C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with pipe insulation pad or cushion for support of bearing surface of piping.

### **2.3 METAL FRAMING SYSTEMS**

- A. Description: MFMA-3, shop or field fabricated pipe support assembly made of steel channels and other components.
- B. Manufacturers:
  - 1. B-Line Systems, Inc.; a division of Cooper Industries
  - 2. ERICO/Michigan Hanger Co.; ERISTRUT Division
  - 3. Power-Strut Division; Tyco International, Ltd.
  - 4. 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.

## **2.4 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. 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. Hilti, Inc.
    - c. ITW Ramset/Red Head
    - d. Powers Fasteners

## **2.5 MISCELLANEOUS MATERIALS**

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

## **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-58 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 non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
  2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120° to 450°F pipes, NPS 4 to NPS 16 (DN 100 to DN 400), 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 (DN 20 to DN 600), 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 (DN 15 to DN 600), if little or no insulation is required.
  5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN 15 to DN 100), 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 non-insulated stationary pipes, NPS 3/4 to NPS 8 (DN 20 to DN 200).
  7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
  8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
  9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2 (DN 15 to DN 50).
  10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8 (DN 10 to DN 200).
  11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3 (DN 10 to DN 80).
  12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
  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 (DN 100 to DN 900), 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 (DN 100 to DN 900), 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 (DN 65 to DN 900), 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 (DN 25 to DN 750), 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 (DN 65 to DN 500), 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 (DN 50 to DN 1050), 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 (DN 50 to DN 600), 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 (DN 50 to DN 750), 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 (DN 20 to DN 500).
  2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), 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°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°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-joint 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. Comply with MSS SP-58 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use powder actuated fasteners or mechanical expansion anchors instead of building attachments where required in concrete construction.
- N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

### **3.2 HANGER AND SUPPORT INSTALLATION**

- A. Steel Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field assembled metal framing systems.
- C. 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.
- D. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- E. Install lateral bracing with pipe hangers and supports to prevent swaying.
- F. 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 (DN 65) 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.
- G. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

### **3.3 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.

### **3.4 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.

### **3.5 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 22 0529**

## **SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**

### **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. Pipe labels
  - 2. Valve tags

#### **1.3 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.

#### **1.4 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 PIPE LABELS**

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.



- B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
  - 1. Flow Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
  - 2. Lettering Size: At least 1-1/2 inches high.

## **2.2 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, Stainless steel, 0.025-inch, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

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

### **3.2 PIPE LABEL INSTALLATION**

- A. Piping Color Coding: Painting of piping is specified in Division 09 Section "Interior Painting."
- B. 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 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
  - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule

1. Natural Gas Piping:
  - a. Background Color: Yellow.
  - b. Letter Color: Black.

**3.3 VALVE TAG INSTALLATION**

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory fabricated equipment units; shutoff valves; faucets; convenience and lawn watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve Tag Application Schedule
  1. Valve Tag Size and Shape:
    - a. Natural Gas: 2 inches round.
  2. Valve Tag Color:
    - a. Natural Gas: Yellow.
  3. Letter Color:
    - a. Natural Gas: Black.

**END OF SECTION 22 0553**

## **SECTION 22 1616 - FACILITY NATURAL GAS 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. Section Includes:
  - 1. Pipes, tubes, and fittings.
  - 2. Piping specialties.
  - 3. Piping and tubing joining materials.
  - 4. Valves.
  - 5. Pressure regulators.
  - 6. Mechanical sleeve seals.
  - 7. Grout.
  - 8. Concrete bases.

#### **1.3 DEFINITIONS**

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Minimum Operating Pressure Ratings:
  - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
  - 2. Service Regulators: 100 psig minimum unless otherwise indicated.
- B. Natural gas System Pressure within Buildings: 0.5 psig or less.

#### **1.5 SUBMITTALS**

- A. Product data for each type of the following:
  - 1. Piping.

2. Piping specialties.
  3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
  4. Pressure regulators. Indicate pressure ratings and capacities.
  5. Dielectric fittings.
  6. Mechanical sleeve seals.
  7. Escutcheons.
- B. Coordination Drawings: Plans and details, drawn to scale, on which natural gas piping is shown and coordinated with other installations, using input from installers of the items involved.
  - C. Site Survey: Plans, drawn to scale, on which natural gas piping is shown and coordinated with other services and utilities.
  - D. Qualification Data: For qualified professional engineer.
  - E. Welding certificates.
  - F. Field quality control reports.
  - G. Operation and Maintenance Data: For motorized gas valves, pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

## **1.6 QUALITY ASSURANCE**

- A. Steel Support 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.

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

## **1.8 PROJECT CONDITIONS**

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility locating service for area where Project is located.

B. Interruption of Existing Natural gas Service: Do not interrupt natural gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural gas supply according to requirements indicated:

1. Notify Architect, Construction Manager, or Owner no fewer than two days in advance of proposed interruption of natural gas service.
2. Do not proceed with interruption of natural gas service without Architect's, Construction Manager's, or Owner's written permission.

## **1.9 COORDINATION**

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

## **PART 2 - PRODUCTS**

### **2.1 PIPES, TUBES, AND FITTINGS**

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  1. Malleable Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
  2. Wrought Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
  3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
  4. Forged Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    - a. Material Group: 1.1.
    - b. End Connections: Threaded or butt welding to match pipe.
    - c. Lapped Face: Not permitted underground.
    - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
  5. Mechanical Couplings:
    - a. Manufacturers - subject to compliance with requirements, provide products by one of the following:
      - 1) Dresser Piping Specialties; Division of Dresser, Inc.
      - 2) Smith-Blair, Inc.
    - b. Steel flanges and tube with epoxy finish.
    - c. Buna-nitrile seals.
    - d. Steel bolts, washers, and nuts.
    - e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

- f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

## **2.2 PIPING SPECIALTIES**

### **A. Appliance Flexible Connectors**

- 1. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
- 2. Operating Pressure Rating: 0.5 psig.
- 3. End Fittings: Zinc-coated steel.
- 4. Threaded Ends: Comply with ASME B1.20.1.
- 5. Maximum Length: 72 inches.

### **B. Weatherproof Vent Cap: Cast or malleable iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.**

## **2.3 JOINING MATERIALS**

### **A. Joint Compound and Tape: Suitable for natural gas.**

### **B. 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.**

## **2.4 MANUAL GAS SHUTOFF VALVES**

### **A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles for where each valve type is applied in various services.**

### **B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.**

- 1. CWP Rating: 125 psig.
- 2. Threaded Ends: Comply with ASME B1.20.1.
- 3. Dry seal Threads on Flare Ends: Comply with ASME B1.20.3.
- 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
- 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
- 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

### **C. Bronze Plug Valves: MSS SP-78.**

- 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. Lee Brass Company
  - b. McDonald, A. Y. Mfg. Company
- 2. Body: Bronze, complying with ASTM B 584.

3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural gas service with "WOG" indicated on valve body.

## 2.5 PRESSURE REGULATORS

### A. General Requirements

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

### B. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers - subject to compliance with requirements, **provide products by one of the following:**
  - a. Canadian Meter Company Inc.
  - b. Eaton Corporation; Controls Division
  - c. Harper Wyman Company
  - d. Maxitrol Company
  - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc plated steel; interchangeable.
4. Diaphragm Plate: Zinc plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet stabilized, mineral filled nylon.
7. Factory Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 1 psig.
10. Capacity: Coordinate the exact size of the pressure regulator with the HVAC unit purchased. (Flow & minimum and maximum natural gas operating pressure.) Basis of design HVAC equipment required natural gas pressure reduction.

## 2.6 DIELECTRIC FITTINGS

### A. 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. McDonald, A. Y. Mfg. Company
    - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
    - f. Wilkins; Zurn Plumbing Products Group
  - 2. Minimum Operating Pressure Rating: 150 psig.
  - 3. Combination fitting of copper alloy and ferrous materials.
  - 4. Insulating materials suitable for natural gas.
  - 5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
- B. 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.; Division of Watts Water Technologies, Inc.
    - d. Wilkins; Zurn Plumbing Products Group
  - 2. Minimum Operating Pressure Rating: 150 psig.
  - 3. Combination fitting of copper alloy and ferrous materials.
  - 4. Insulating materials suitable for natural gas.
  - 5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
- C. 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. Minimum Operating Pressure Rating: 150 psig.
  - 3. Companion flange assembly for field assembly.
  - 4. Include flanges, full-face or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
  - 5. Insulating materials suitable for natural gas.
  - 6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

## 2.7 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.



## **2.8 MECHANICAL SLEEVE SEALS**

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
  - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. Advance Products & Systems, Inc.
    - b. Calpico Inc.
    - c. Metraflex Company (The)
    - d. Pipeline Seal and Insulator, Inc.
  - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
  - 3. Pressure Plates: Carbon steel or Stainless steel.
  - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or Stainless steel of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

## **2.9 ESCUTCHEONS**

- A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
- B. One-Piece, Deep pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome plated finish.
- C. One-Piece, Cast brass Escutcheons: With set screw.
  - 1. Finish: Polished chrome plated or rough brass.
- D. Split-Casting, Cast brass Escutcheons: With concealed hinge and set screw.
  - 1. Finish: Polished chrome plated or rough brass.
- E. One-Piece, Stamped-Steel Escutcheons: With set screw or spring clips and chrome plated finish.
- F. Split-Plate, Stamped-Steel Escutcheons: With exposed-rivet hinge, setscrew or spring clips, and chrome plated finish.
- G. One-Piece, Floor plate Escutcheons: Cast iron floor plate.
- H. Split-Casting, Floor plate Escutcheons: Cast brass with concealed hinge and set screw.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine roughing-in for natural gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

### **3.3 OUTDOOR PIPING INSTALLATION**

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural gas piping.
- B. Install fittings for changes in direction and branch connections.
- C. Aboveground, Exterior Wall Pipe 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.
  - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
  - 2. Install cast iron "wall pipes" for sleeves 6 inches and larger in diameter.
- D. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### **3.4 INDOOR PIPING INSTALLATION**

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.

- H. Install natural gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install escutcheons at penetrations of interior walls, ceilings, and floors.
  - 1. New Piping:
    - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern type.
    - b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast brass type with polished chrome plated finish.
    - c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    - d. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast brass type with polished chrome plated finish.
    - e. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
    - f. Piping in Unfinished Service Spaces: One-piece, cast brass type with rough-brass finish.
    - g. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with setscrew or spring clips.
    - h. Piping in Equipment Rooms: One-piece, cast brass type.
    - i. Piping in Equipment Rooms: One-piece, stamped-steel type with setscrew or spring clips.
    - j. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor plate type.
  - 2. Existing Piping:
    - a. Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast brass type with chrome plated finish.
    - b. Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
    - c. Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast brass type with chrome plated finish.
    - d. Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
    - e. Piping in Unfinished Service Spaces: Split-casting, cast brass type with rough-brass finish.
    - f. Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and setscrew or spring clips.
    - g. Piping in Equipment Rooms: Split-casting, cast brass type.
    - h. Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
    - i. Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor plate type.
- L. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- M. Verify final equipment locations for roughing-in.
- N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

- O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
  - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 4 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- Q. Concealed Location Installations: Except as specified below, install concealed natural gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
  - 1. Above Accessible Ceilings: Natural gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
  - 2. In Floors: Install natural gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
  - 3. In Floor Channels: Install natural gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
  - 4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
    - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
  - 5. Prohibited Locations:
    - a. Do not install natural gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    - b. Do not install natural gas piping in solid walls or partitions.
- R. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- S. Connect branch piping from top or side of horizontal piping.
- T. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- U. Do not use natural gas piping as grounding electrode.

### **3.5 VALVE INSTALLATION**

- A. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

### **3.6 PIPING JOINT CONSTRUCTION**

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
  - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
  - 2. Cut threads full and clean using sharp dies.
  - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
  - 4. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 5. 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.

### **3.7 HANGER AND SUPPORT INSTALLATION**

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
  - 2. NPS 1-1/4 (DN 32): Maximum span, 108 inches; minimum rod size, 3/8 inch.
  - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches; minimum rod size, 3/8 inch.
  - 4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet; minimum rod size, 1/2 inch.
  - 5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

### **3.8 CONNECTIONS**

- A. Install natural gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- B. Install piping adjacent to appliances to allow service and maintenance of appliances.
- C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

### **3.9 LABELING AND IDENTIFYING**

- A. Comply with requirements in Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment" for piping and valve identification.

### **3.10 PAINTING**

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural gas piping.
- B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory applied paint or protective coating.
  - 1. Alkyd System: MPI EXT 5.1D.
    - a. Prime Coat: Alkyd anticorrosive metal primer.
    - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
    - c. Topcoat: Exterior alkyd enamel gloss.
    - d. Color: Yellow.
- C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory applied paint or protective coating.
  - 1. Latex over Alkyd Primer System: MPI INT 5.1Q.
    - a. Prime Coat: Alkyd anticorrosive metal primer.
    - b. Intermediate Coat: Interior latex matching topcoat.
    - c. Topcoat: Interior latex gloss.
    - d. Color: Yellow.
  - 2. Alkyd System: MPI INT 5.1E.
    - a. Prime Coat: Alkyd anticorrosive metal primer.
    - b. Intermediate Coat: Interior alkyd matching topcoat.
    - c. Topcoat: Interior alkyd gloss.
    - d. Color: Yellow.
- D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

### **3.11 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.
- C. Natural gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.12 DEMONSTRATION**

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

### **3.13 OUTDOOR PIPING SCHEDULE**

- A. Aboveground natural gas piping shall be the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints.

### **3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG**

- A. Aboveground piping shall be one of the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints. (2" and smaller)
  - 2. Steel pipe with wrought-steel fittings and welded joints. (2 1/2" and larger)
- B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- C. Containment Conduit Vent Piping: Steel pipe with malleable iron fittings and threaded or wrought steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

### **3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE**

- A. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:
  - 1. One-piece, bronze ball valve with bronze trim.
  - 2. Bronze plug valve.
- B. Valves in branch piping for single appliance shall be the following:
  - 1. One-piece, bronze ball valve with bronze trim.
  - 2. Bronze plug valve.

**END OF SECTION 22 1616**

## HVAC INDEX

SECTION	DESCRIPTION	PAGE NO.
23 0500	Common Work Results for HVAC	1 - 18
23 0510	Basic Electrical Requirements for HVAC Equipment	1 - 5
23 0511	Enclosed Motor Controllers for HVAC Equipment	1 - 7
23 0512	Variable Frequency Motor Controllers for HVAC Equipment	1 - 12
23 0513	Common Motor Requirements for HVAC Equipment	1 - 3
23 0519	Meters and Gauges for HVAC Piping	1 - 5
23 0523	General - Duty Valves for HVAC Piping	1 - 9
23 0529	Hangers and Supports for HVAC Piping and Equipment	1 - 9
23 0548.13	Vibration Controls for HVAC Piping and Equipment	1 - 6
23 0553	Identification for HVAC Piping and Equipment	1 - 4
23 0593	Testing, Adjusting, and Balancing for HVAC	1 - 15
23 0713	Duct Insulation	1 - 12
23 0716	HVAC Equipment Insulation	1 - 6
23 0719	HVAC Piping Insulation	1 - 8
23 0801	Commissioning of HVAC	1 - 12
23 0900	Automatic Temperature Controls for HVAC	1 - 30
23 0993	Sequence of Operations for HVAC Controls	1 - 31
23 2113	Hydronic Piping	1 - 11
23 2123	Hydronic Pumps	1 - 5
23 2513	Water Treatment for Closed Loop Hydronic System	1 - 7
23 3113	Metal Ducts	1 - 9
23 3300	Air Duct Accessories	1 - 8
23 7413	Packaged Rooftop Air Conditioning Units	1 - 19



## **SECTION 23 0500 - COMMON WORK RESULTS 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Definitions
  - 2. Permits, Codes, and Inspections.
  - 3. Visiting Premises
  - 4. Dielectric fittings.
  - 5. Sleeves.
  - 6. HVAC demolition.
  - 7. Painting and finishing.
  - 8. Fire stopping.
  - 9. Roof curbs.
  - 10. Concrete bases.
  - 11. Supports and anchorages.
  - 12. Grout.
  - 13. Access doors and panels.

#### **1.3 DEFINITIONS**

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

## **1.4 SUBMITTALS**

- A. Product data for the following:
  - 1. Escutcheons.
  - 2. Interference/Coordination drawings.
  - 3. Roof curbs.
  - 4. Access doors and panels.

## **1.5 PERMITS, CODES, AND INSPECTIONS**

- A. Contractor shall obtain and pay for all permits and inspections required by laws, ordinances, rules, and regulations having jurisdiction for work included under this Contract, and shall submit approval certificates to the Architect.
- B. The HVAC installation shall comply fully with:
  - 1. All local, county and state laws, ordinances and regulations having jurisdiction and as applicable to the HVAC installations.
  - 2. All approved published instructions set forth by manufacturers of equipment furnished or installed on this project.
- C. The HVAC installation and all components shall be in compliance with all applicable codes and ordinances adopted by the local authority having jurisdiction. Unless noted otherwise in the applicable codes and ordinances adopted by the local authority having jurisdiction, requirements of the latest or state-adopted edition of the following Standards shall apply.
  - 1. American Society for Testing and Materials (ASTM)
  - 2. Americans with Disabilities Act (ADA)
  - 3. International Building Code (IBC)
  - 4. International Fire Code (IFC)
  - 5. International Energy Conservation Code (IECC)
  - 6. National Electric Code (NEC)
  - 7. National Fire Protection Association (NFPA)
  - 8. National Safety Code
  - 9. Occupational Safety and Health Act (OSHA)
  - 10. Sheet Metal & Air Conditioning Contractors National Association Standards (SMACNA)
  - 11. Underwriter's Laboratories, Inc. (UL)
- D. Submit certificates issued to authorized agencies which indicate the work conforms to the above requirements, as well as any additional certificates as may be required for the performance of this contract work.
- E. Certificate of Inspection: The Contractor shall procure and pay for the Certificate of Inspection from the municipality-approved inspection agency and deliver it to the Architect before final payment is made.

## **1.6 VISITING PREMISES**

- A. All bidders are encouraged to visit the project site prior to submitting a bid proposal. The Contractor's is responsible for becoming familiar with the existing conditions of the project prior to submitting a bid proposal. Sufficient allowances shall be included in the bid proposal to perform work that may not be illustrated on the drawings, but due to existing conditions can be reasonably inferred as belonging to work required to complete this contract. Items which cannot be determined from a visual inspection, such as unforeseen conditions that are buried within walls, beneath concrete floors, or above hard ceilings, would not apply.
- B. By submission of a bid, the Contractor is attesting that responsible personnel are aware and familiar with all existing pertinent conditions.
- C. Contractor shall verify all measurements and dimensions at the site which may materially affect the contract price prior to submitting a bid proposal.

## **1.7 QUALITY ASSURANCE**

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
  - 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. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

## **1.8 DRAWINGS AND SPECIFICATIONS**

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable mechanical systems complete in every respect.
- B. Any apparatus, appliance, material or work not typically shown on drawings as standard industry practice but is mentioned in the specifications, or vice versa, shall be provided by the HVAC Trade without additional expense to the Owner.
- C. The drawings are diagrammatic, intending to show general arrangement and location of system components, and are not intended to be rigid in detail.
- D. Due to the small scale of the drawings, all offsets and fittings required for a complete installation may not be shown but shall be provided at no change in Contract price.

- E. The equipment schedules shown on the drawings list the manufacturer used as the basis of design in the preparation of the Bid Drawings.
1. The equipment specifications list that manufacturer as well as other manufacturers the Engineer, Architect and/or Owner find acceptable from a performance and product quality perspective, but not as the basis of design, provided the requirements of the specifications are met.
  2. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they offer products which meet all of the specified requirements.
    - a. Manufacturers shall only offer proposals that meet the specified items.
    - b. Substitutions that in the engineer's opinion, do not meet the specified requirements due to variations in manufacturing or available options, will not be approved.
  3. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they have a positive or negative monetary impact on the design shown on the Bid Drawings.
  4. In addition, listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether the dimensions of these products will have a negative impact on the space allotted for this equipment.
  5. If the Contractor or his Subcontractors decide to submit a product or manufacturer for approval that is listed as acceptable in the specifications but is different from the product or manufacturer scheduled on the drawings, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the plumbing system(s) and/or the fire protection system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, etc., between the scheduled item and the equipment item used.
  6. If the Contractor or his Subcontractors decide to submit a product or manufacturer for approval that is not listed as acceptable in the specifications, and approval to use the substituted equipment is granted, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the plumbing system(s) and/or the fire protection system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, or any other difference, between the scheduled item and the equipment item used.
  7. Use of a product or manufacturer not scheduled on the Bid Drawings constitutes a representation that:
    - a. The HVAC Trade has investigated the proposed product and determined that the product can be installed within the space allotted.
    - b. The HVAC Trade will coordinate the installation of product used into the work
    - c. The HVAC Trade will be responsible for making all changes as may be required to make the work complete in all respects; waives all claims for additional costs under his responsibility, which may subsequently become apparent.

## **1.9 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Deliver ducts with shop-applied plastic covers over each opening of every duct. Prior to applying the plastic covers on each duct, vacuum all dirt and debris from its interior. Maintain the plastic covers through shipping and storage. Handle ducts to prevent damage to the ducts and to the plastic covers. If a duct's plastic cover(s) is damaged or comes loose, re-vacuum the interior of the duct and apply new plastic covers. The plastic cover shall be maintained over the openings of each duct until that duct is ready to be installed.

## **PART 2 - PRODUCTS**

### **2.1 NAMEPLATE DATA**

- A. Provide factory-installed, permanent operational data nameplate on each item of HVAC equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

### **2.2 SLEEVES**

- A. Galvanized Steel Sheet (For Ductwork Only): 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

### **2.3 ESCUTCHEONS**

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome plated finish.
- C. One-Piece, Cast brass Type: With set screw.
  - 1. Finish: Polished chrome plated and rough brass.
- D. Split-Casting, Cast brass Type: With concealed hinge and set screw.
  - 1. Finish: Polished chrome plated and rough brass.
- E. One-Piece, Stamped-Steel Type: With spring clips and chrome plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome plated finish.
- G. One-Piece, Floor plate Type: Cast iron floor plate.
- H. Split-Casting, Floor plate Type: Cast brass with concealed hinge and set screw, and chrome plated finish.

## **2.4 GROUT**

- A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic cement grout.
  - 1. Characteristics: Post hardening, volume adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
  - 2. Design Mix: 5000-psi, 28-day compressive strength.
  - 3. Packaging: Premixed and factory packaged.

## **2.5 METAL SUPPORTS AND ANCHORAGES**

- A. Structural design shall be provided through the HVAC trade by a civil or structural Engineer who is registered in the Commonwealth of Pennsylvania.
- B. Details of all structural steel shall be provided in shop drawing format. All structural steel shop drawings shall be stamped by the HVAC Trade's design Engineer prior to submittal.
- C. The design, materials, fabrication and erection shall conform to "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" of the American Institute of Steel Construction, "Code of Standard Practice for Steel Buildings and Bridges", of the American Institute of Steel Construction, and also, when applicable, shall conform to the "Code for Welding Building Construction" of the American Welding Society.
- D. Steel angles, channels, and plate shall be in accord with ASTM A36.
- E. Bolts, including nuts and washers, used for fabricating steel members shall be in accord with ASTM A325.
- F. Steel members, including fasteners, exposed to weather shall be galvanized.
- G. Refer to Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" for additional requirements for hanging and supporting HVAC piping, ductwork and equipment.

## **2.6 FIRESTOPPING**

- A. Provide penetration firestopping that is produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
  - 1. Nelson Firestop Products
  - 2. 3M Fire Protection Products
  - 3. Tremco, Inc.; Tremco Fire Protection Systems Group
  - 4. USG Corporation
- C. Penetrations in Fire-Resistance-Rated Walls: Provide penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
  - 1. Fire-resistance-rated walls include fire walls, fire barrier walls, smoke-barrier walls and fire partitions.
  - 2. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

- D. Penetrations in Horizontal Assemblies: Provide penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
  - 1. Horizontal assemblies include floors, floor/ceiling assemblies and ceiling membranes of roof/ceiling assemblies. Refer to the Architectural Drawings for locations and types of rated horizontal assemblies.
  - 2. F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.
- E. Penetrations in Smoke Barriers: Provide penetration firestopping with ratings determined per UL 1479.
  - 1. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at 0.30-inch wg at both ambient and elevated temperatures.
- F. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping manufacturer and approved by qualified testing and inspecting agency for firestopping indicated.

## 2.7 ROOF CURBS

- A. All roof curbs shall be sloped to match the pitch of the roof to provide a level equipment installation.
- B. The HVAC trade shall furnish all roof mounted air handling units and packaged rooftop air conditioning units with factory-built vibration isolation roof curb rails. Refer to Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment" for requirements.
- C. The HVAC trade shall furnish all other roof mounted equipment items, such as gravity roof ventilators, roof exhaust fans, etc., with factory-built roof curbs. Roof curbs serving equipment items shall be furnished by their respective equipment manufacturers. Refer to equipment specifications in other Division 23 Sections for roof curb requirements that are indicated to be furnished by the particular equipment manufacturers.
- D. The HVAC trade shall furnish factory-built roof curbs at all duct openings.
  - 1. Factory built roof curbs shall be of box section design, 18-gauge galvanized steel with continuous welded corner seams, factory installed wood nailer and insulated with 1-1/2-inch, 3-pound density rigid fiberglass board.
  - 2. The base of each curb shall be manufactured to match the roof pitch while maintaining a level equipment installation or a vertical duct installation.
  - 3. Minimum installed height of curb shall be 24 inches above the finished surface of the roof. Coordinate the height of the roofing materials with the Architectural Drawings and with the Roofing trade.
  - 4. Roof curbs shall be similar to the Roof Products Systems (RPS) Type RC-4.

## 2.8 ACCESS DOORS AND PANELS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - 1. Bar-Co., Inc.
  - 2. J.L. Industries
  - 3. Karp Associates, Inc.
  - 4. Milcor Division, Inryco, Inc.
  - 5. Nystrom, Inc.

- B. Steel Access Doors and Frames: Factory fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded, with welds ground smooth and flush with adjacent surfaces.
  - 1. Door material - 16-gauge steel, having a factory-prime finish suitable for field painting except as follows:
    - a. For kitchens, toilet rooms, janitor's closet, or elsewhere as indicated, 16-gauge stainless steel having a No. 4 finish.
  - 2. Frame material - same material and finish as door, with the following features:
    - a. For installation in masonry, concrete, ceramic tile, or wood paneling: 1 inch-wide-exposed perimeter flange and adjustable metal masonry anchors.
    - b. For gypsum wallboard or plaster: Perforated flanges with wallboard bead.
    - c. For full-bed plaster applications: Galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
- C. Flush Panel Doors: Furnish with concealed spring hinges or concealed continuous piano hinge.
- D. Fire rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
  - 1. Fire Resistance Rating: Not less than 1½-hours.
- E. Locking Devices: Flush, screwdriver operated cam locks.
- F. Size: Doors and/or panels shall be of sufficient size for the intended function, but not less than 12 inches by 16 inches.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION - GENERAL**

- A. Before any HVAC construction work is performed and/or any equipment and materials are ordered, the HVAC Trade shall examine the project area(s) where HVAC work will be performed to verify actual locations, dimensions, and other conditions that may affect the installation of HVAC equipment, materials and associated work.

### **3.2 COORDINATION**

- A. Arrange for **pipe spaces, chases, slots, and openings** in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."



D. Cooperation and Coordination with Other Trades:

1. This HVAC trade must cooperate completely and coordinate work with the General Trade and other trades providing equipment under this division and other divisions of the specifications.
2. Interference drawings shall be prepared as a combined effort of all trades. Each trade shall proceed with their own set of drawings on electronic backgrounds in AutoCAD format prepared by the HVAC trade. The HVAC trade shall start its drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.
3. After the HVAC trade has finished, it shall forward one print along with an electronic file to the Plumbing trade that, in turn, will show and coordinate the plumbing work on the combined plans with the other trades. After the Plumbing trade has finished, it shall forward one print along with an electronic file to the Electrical trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades. After the Electrical trade has finished, it shall forward one print along with an electronic file to the Fire Protection trade that, in turn, will show and coordinate the fire protection work on the combined plans with the other trades.
4. Interference plans and elevations shall show in detail the location of the following items that require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the article contained in Part 3 of this Section entitled "Space Priority".
  - a. In addition, show mechanical and electrical work in equipment rooms.
  - b. On the interference drawings, show all electrical conduits which are 1-1/2" and larger.
5. Reproducible copies along with an electronic file of the finished interference drawings shall be submitted to the Architect for record and approval before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
6. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.

### 3.3 HVAC DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
  1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material. Remove and dispose the contents of any piping indicated to be removed, including but not limited to glycol, refrigerant, or fuel oil in a lawful manner compliant with all applicable codes, ordinances, and authorities having jurisdiction.
  2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
  3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
  4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
  5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
  6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
  7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

- C. Refrigerant: Remove refrigerant from mechanical equipment to be selectively demolished according to 40 CFR 82 and regulations of authorities having jurisdiction.
- D. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.
- E. The HVAC trade shall demolish all work as outlined on the drawings.
- F. The Owner shall decide the disposition of all removed materials. The HVAC trade shall deliver to the Owner all materials identified to be salvaged. The HVAC trade shall properly dispose of all materials not identified to be salvaged.
- G. Refer to the paragraph entitled "Special Conditions Related to HVAC Work" in this section for requirements related to utility shut downs, capping of existing system, and air balancing services which may be required.
- H. When demolishing existing equipment, the HVAC trade shall remove all existing piping, ductwork, insulation, supports, hangers, hanger rods, anchor bolts, structural steel, and concrete pads related to the work being removed. When demolishing piping or ductwork branch run outs, remove the entire branch which is accessible above lay-in ceilings or accessible during the construction period back to the main, unless otherwise noted. When demolishing equipment and diffusers and the branch run outs are inaccessible, cap, seal, and abandon the branch run outs in an approved manner.
- I. Where demolition of work results in unsightly openings in occupied spaces or jeopardizes the integrity of a fire or smoke barrier, the opening shall be patched in accordance with the paragraph in this section entitled "Cutting and Patching".
- J. Where demolition requires the removal of a concrete equipment pad, remove the pad, cut all anchor bolts, dowel pins, and steel bases off flush with the floor so as to eliminate any tripping hazard. Fill any openings, voids, or holes with a fine cement grout or another appropriate floor patching material. Provide surface finish to match adjacent flooring material.

### **3.4 CUTTING AND PATCHING**

- A. Cutting and patching shall be in accordance with the General Conditions and the applicable Section of Division 01, General Requirements.
- B. The HVAC trade shall seal all openings he has utilized in fire rated floors, ceilings or partitions after his work has been installed. The material used for sealing the openings shall have a fire-rating equal to or greater than the rating of the floor, ceiling or partition material.
- C. The HVAC trade shall be responsible for providing all cutting, patching, and finishing of existing construction which is not specifically shown on the Architectural Drawings and which is required for the proper installation of his equipment and materials which are to be installed in the existing portion of this project. This work shall also be provided when removing existing equipment and materials. All cutting shall be kept to an absolute minimum consistent with the requirements of the project.
- D. Cutting, patching and finishing shall be performed by workmen skilled in this type of work. All patching shall be done utilizing materials of the same quality and texture as the adjacent undisturbed areas. All finishing shall match the undisturbed adjacent areas. Painting of the final finished areas, where general construction work occurs, will be the responsibility of the General Trade. Painting of the final finished areas, where no general construction work occurs, shall be the responsibility of the HVAC trade. The HVAC trade shall paint entire plane in which damage occurs whether the surface is a wall or a ceiling.

- E. No cutting shall be done which may affect the building structurally or architecturally without first consulting with the General Trade and then securing the approval of the Architect. Cutting shall be accomplished in such a manner as not to cause damage to the building or leave unsightly surfaces which cannot be concealed by plates, escutcheons or other construction. Where such unsightly conditions are caused, the HVAC trade shall be required, at his own expense, to repair the damaged areas. Note: all holes or openings in existing concrete or masonry shall be drilled, core bored or saw cut.
- F. Where an opening is cut into a block or brick wall for the purpose of ductwork or piping to pass through the wall, the HVAC trade shall be responsible for furnishing and installing a properly sized lintel to support the block or brick above the opening.
- G. Where present equipment or material is removed and unused openings remain in walls, floors, partitions, roof deck, etc., the HVAC trade shall properly patch all such openings.
- H. The HVAC Contractor shall patch the existing duct openings serving existing rooftop air handling units scheduled for replacement. For each instance, the HVAC contractor shall remove the rooftop air handling unit and install new roof deck to cover the existing openings prior to measuring and cutting new roof deck opening of the exact size, and in the exact locations necessary to mate with the replacement equipment leaving the smallest air gap possible between the connecting ductwork and the roof deck. This work shall be performed to prevent the transmission of sound generated by the rooftop unit to the space below the roof deck.

### **3.5 SPECIAL CONDITIONS RELATED TO HVAC WORK**

- A. During the course of construction, cap or otherwise seal off, in an approved manner, those portions of the piping or duct system in which work is not being performed, in order to prevent the entry of dirt or dust. Should the HVAC trade fail to cover open ends of ducts, he may be required to vacuum the entire duct system and remove sections of ductwork for inspection.
- B. The HVAC trade shall coordinate all utility shutdowns with the Owner to determine when the most advantageous time is for the Owner to accommodate the utility shutdown. The HVAC trade shall coordinate the utility shutdown a minimum of **7 days** in advance.
- C. When the HVAC trade demolishes only a portion of an existing air system and the remainder of the system is to remain in service, the Testing and Balancing trade shall measure the air flow in the undisturbed portions of system prior to disconnecting work in the construction areas. The Testing and Balancing trade shall rebalance the affected systems to these measurements immediately following the disconnection of the ductwork being demolished/modified and also immediately after placing the new/modified system into service.
- D. Install equipment along with control devices and all replaceable fittings with sufficient clearance for operation and maintenance functions.
- E. Do not install piping and ductwork in transformer vaults, elevator equipment rooms or electrical equipment rooms unless the piping and/or ductwork serves HVAC equipment located in that room and is dedicated to provide cooling and/or heating to that room. Do not install piping and ductwork adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.
- F. Lay out the work and establish all heights required for installation.
- G. Provide safety guards for all pulleys, belt-drives and rotating equipment. Safety requirements of OSHA shall be met.

### 3.6 SPACE PRIORITY

- A. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
  - 1. Gravity flow piping systems.
  - 2. Vent piping systems.
  - 3. Ceiling recessed lighting fixtures.
  - 4. Concealed air terminal units, fans.
  - 5. Air duct systems.
  - 6. Sprinkler systems piping.
  - 7. Forced flow piping systems.
  - 8. Electrical conduit, wiring, control wiring.
- B. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
- C. Change in order of priority is permissible by mutual agreement of all affected trades.
- D. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
- E. The work of a particular trade shall not obstruct access for installation, operation, and maintenance of the Work, materials and equipment of another trade.

### 3.7 SLEEVES

- A. Sleeves are not required for core-drilled holes.
- B. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **2 inches** above finished floor level. Extend cast iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
  - 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
    - a. Steel Pipe Sleeves: For pipes smaller than NPS 8 (DN 200).
  - 4. Seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for material and installation requirements of joint sealants.
- C. Aboveground, Interior wall Pipe Penetrations: Seal penetrations through all walls identified to have an STC rating. Refer to the Architectural Drawings to determine the walls where this requirement applies.
  - 1. Sealant shall be an acoustical type sealant; refer to Division 07 for requirements.

D. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 for material and installation requirements of firestopping.

### **3.8 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS**

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.
- E. Install all new, relocated, or owner furnished equipment in accord with the manufacturer's written installation instructions.

### **3.9 PAINTING**

- A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

### **3.10 CONCRETE BASES**

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions.
  - 1. Construct concrete bases of dimensions indicated, but not less than 3 inches larger in both directions than supported unit.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
  - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
  - 7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03.

### **3.11 ERECTION OF METAL SUPPORTS AND ANCHORAGES**

- A. Provide all materials, equipment, supplies and labor necessary to construct all miscellaneous steel required for supporting piping, ductwork and equipment for installation of the HVAC system. All miscellaneous steel, metal supports and anchorages required for supporting ductwork, piping and equipment is not shown on the Drawings, but shall be provided.
- B. All structural steel shall be designed to attach to the main building structure in such a manner as to not overstress this structure. Reinforcement of the building structure may be required in work areas located in existing buildings and in areas where the HVAC trade has relocated ductwork, piping, and equipment to areas other than is shown on the Drawings.
- C. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- D. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- E. Shop and Field Welding: Shop and field welding shall be in accordance with AWS D1.1.

### **3.12 GROUTING**

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

### **3.13 FINAL CLEANING**

- A. Provide in accordance with Division 01 Section 01 7700 CLOSEOUT PROCEDURES.

### **3.14 WARRANTIES**

- A. Provide in accordance with Division 01 Section 01 7700 CLOSEOUT PROCEDURES and as stated below.
- B. Refer to individual equipment specifications for additional warranty requirements. If a contradiction exists, the most demanding requirements shall prevail.
- C. Compile and assemble the warranties specified in Division 23 into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

- D. Provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, address, and telephone numbers and procedures for filing a claim and obtaining warranty services.
- E. Submit a single warranty stating that all portions of the work are in accordance with Contract requirements. Warrant all work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. Within 24 hours after notification, correct any deficiencies that occur during the warranty period at no additional cost to Owner, all to the satisfaction of the Owner and Architect. Obtain similar warranties from subcontractors, manufacturers, suppliers and sub-trade specialists.
- F. Any material, equipment or appurtenance whose operation or performance does not comply with the requirements of the Contract Documents or that are damaged prior to acceptance will be held as defective and shall be removed and properly replaced at no additional cost to the Owner.

### **3.15 FIRESTOPPING**

- A. Firestopping is required in the following locations:
  - 1. Where exposed and concealed horizontal ducts penetrate fire rated walls and shaft walls, except where fire dampers are installed in ducts.
  - 2. Where exposed and concealed vertical ducts penetrate rated and non-rated floors, except where fire dampers are installed in ducts.
  - 3. Where exposed and concealed horizontal pipes penetrate fire rated walls and shaft walls.
  - 4. Where exposed and concealed vertical pipes penetrate rated and non-rated floors.
- B. Clean surfaces to be in contact with firestopping materials of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.
- C. Install materials in accordance with printed instructions of the UL Fire Resistance Directory and per manufacturer's published instructions.
- D. Place firestopping in annular space around fire dampers before installation of damper's anchoring flanges which are installed in accordance with fire damper manufacturer's recommendations.
- E. Where large openings are created in walls or floors to permit installation of ducts or other items, close unused portions of opening with firestopping material tested for the application.
- F. Fill annular space between duct and sleeve, with approved material. Depth of material shall be in accord with laboratory tests for 1, 2, or 3 hour rated assemblies.
- G. Damming material may be temporary non-fire approved, or permanent fire-approved. Where permanent fire-approved damming material is used, depth of firestopping material may be decreased in accord with manufacturer's recommendations. Temporary damming material shall be removed after installation of firestopping material.
- H. Seal all gaps or voids in cured foam with material to match the firestopping material.
- I. Trim excess cured foam from around all openings and leave smooth, flush surface.
- J. Position metal collar on duct penetrating floors or walls in air plenums and air shafts. Secure neck of collar to duct with screws.

### **3.16 INSTALLATION OF ROOF CURBS**

- A. Prefabricated roof curbs shall be furnished and installed by the HVAC trade. All roof curbs, including base flashing and leveling shims, shall be installed by **the HVAC trade**. Counter flashing and leveling shims shall be provided by **the HVAC trade**.
- B. Rooftop curbs, for equipment or components that require service, shall be located to provide a minimum of 10'-0" clearance from the face of the equipment to adjacent roof edges.
- C. Cutting of roof deck will be performed by **the HVAC trade**. The HVAC Trade shall coordinate the exact opening sizes with the entity designated to cut the roof deck to ensure roof deck is not over-cut. Verify the exact opening requirements with the unit manufacturer.
  - 1. For rooftop units, the void space on the interior of the roof curb shall be completely filled with alternating layers of flexible sound barrier and acoustical insulation for sound attenuation purposes by the HVAC Trade. Refer to Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment" for in-curb acoustical treatment requirements.
  - 2. All openings between the ducts and the roof deck, within the curb area, shall be caulked with Dow Corning 799 Silicone Metal Building Sealant by the HVAC Trade.

### **3.17 INSTALLATION OF ACCESS DOORS AND PANELS**

- A. Access Doors and Panels:
  - 1. Where HVAC devices which require periodic maintenance, cleaning or adjustment will be concealed in shafts, chases, above drywall ceilings and in other inaccessible general construction work, the HVAC Trade shall furnish and install access doors and panels for all such devices. These HVAC devices include, but are not limited to, valves, traps, air vents, cleanouts, damper regulators, fire dampers, smoke dampers, controls and other devices,
  - 2. The HVAC Trade in conjunction with the General Trade shall determine door and/or panel locations subject to the Architect's approval. Locate items to be made accessible through doors and/or panels so that the doors and/or panels may be installed with not less than 6 inches between an edge and the surface of any intersecting construction or opening.
  - 3. Access doors and panels shall be installed in accordance with the manufacturers written recommendations and Division 08 of these Specifications.

### **3.18 DUCT MOUNTED SMOKE DETECTOR INSTALLATION**

- A. Refer to Division 23 Section 23 0510 "Basic Electrical Requirements for HVAC Equipment" for duct-mounted smoke detector requirements.

### **3.19 TEMPORARY HEATING, COOLING, AND DEHUMIDIFICATION**

- A. Provide specified temporary services in accordance with Division 01 Section 01 5000 "TEMPORARY FACILITIES AND CONTROLS" and as indicated on the drawings.
- B. Provide temporary services to facilitate scheduled completion of the work for every entity authorized to do work at project site. Maintain interior conditions as required for each type of work to be performed.
- C. Refer to Division 01 for requirements.



### **3.20 FINAL HVAC CONNECTIONS**

- A. Provide rough-in and final connection of all HVAC services needed for equipment provided by the Owner or by other trades. Shop Drawings will be furnished by those providing the equipment. These Drawings shall be checked by the trade responsible for rough-in and final connections before submission to the Architect for approval. The work shall be done in accordance with the approved Shop Drawings.
- B. In general, connection and termination points are given in the Contract Documents. Where not given or where conflicts occur, refer the question to the Architect for a binding decision.

### **3.21 MAINTENANCE MANUALS**

- A. Provide in accordance with Division 01 Section 01 7823 OPERATION AND MAINTENANCE DATA and as stated below.
- B. Include the following information for equipment items:
  - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
  - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
  - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
  - 4. Servicing instructions and lubrication charts and schedules.
  - 5. Provide a cover sheet for each manual including the project name, Architect's name and contact information, Engineer's name and contact information, and Division 23 contractor's name and contact information.
  - 6. Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
  - 7. Manufacturer's data of each piece of equipment including:
    - a. Installation instructions.
    - b. Drawings and Specifications.
    - c. Parts list, including recommended items to be stocked.
    - d. Complete wiring diagrams.
    - e. Marked or changed prints locating all concealed parts and all variations from the original system design.
    - f. Test and inspection certificates.

### **3.22 RECORD DOCUMENTS**

- A. Provide in accordance with Division 01 Section 01 7839 PROJECT RECORD DOCUMENTS and as stated below.
- B. Indicate installed conditions for the following:
  - 1. Ductwork.
  - 2. Duct Accessories
  - 3. Piping.
  - 4. Piping Accessories.
  - 5. Valves.

6. HVAC Equipment.
7. Automatic Temperature Control Panels, Control Devices, and Sensors.
8. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

### **3.23 DEMONSTRATION AND TRAINING**

- A. Provide in accordance with Division 01 Section 01 7900 DEMONSTRATION AND TRAINING and as stated below.
- B. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.
- C. The following is a list system that require Demonstration and Training, refer to the individual specification sections for additional training requirements:
  1. Automatic Temperature Controls
  2. HVAC Equipment.
  3. Duct Accessories
  4. Piping Accessories.
  5. Valves.

**END OF SECTION 23 0500**

## **SECTION 23 0510 - BASIC ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section includes the following:
  - 1. Disconnect Switches
  - 2. Fuses
  - 3. Electrical Requirements - General
  - 4. Duct Mounted Smoke Detector Installation
  - 5. Piping and Ductwork Coordination

#### **1.3 SUBMITTALS**

- A. Product Data
  - 1. For each type of disconnect switch. Include dimensions and electrical characteristics, ratings, and finishes. Also include dimensioned plans, elevations, sections, and details, Include the following:
    - a. Wiring Diagrams: Power wiring.
  - 2. For each type of fuse. Include electrical characteristics and ratings.

#### **1.4 QUALITY ASSURANCE**

- A. Source Limitations: Obtain disconnect switches of a single type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- C. Comply with NFPA 70.

#### **1.5 DELIVERY, STORAGE, AND HANDLING**

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

- B. If stored in areas subject to weather, cover disconnect switches and fuses to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside equipment; install electric heating of sufficient wattage to prevent condensation.

## **1.6 COORDINATION**

- A. Coordinate layout and installation of disconnect switches with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of disconnect switches with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each disconnect switch with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

## **PART 2 - PRODUCTS**

### **2.1 DISCONNECT SWITCHES**

- A. Acceptable Manufacturers
  - 1. Square D
  - 2. Cutler Hammer
  - 3. General Electric
  - 4. Siemens
- B. Heavy Duty Safety Switches: Provide surface-mounted, heavy-duty type, sheet-steel enclosed safety switches of types, sizes and electrical characteristics indicated on the drawings.
- C. Provide switches with quick-make, quick-break type operation, with switchblades that are visible in the 'OFF' position with door open.
- D. Operating handle shall be an integral part of the enclosure base the operating position shall be easily recognizable and pad-lockable in OFF position.
- E. Current carrying parts shall be constructed of 98% conductivity copper, with silver-tungsten type switch contacts and positive pressure type reinforced fuse clips.
- F. Enclosures shall meet environmental conditions of installed location.
  - 1. Indoor Locations: NEMA 250, Type 1
  - 2. Outdoor Locations: NEMA 250, Type 3R.
- G. Provide motor and motor starter disconnects with horsepower ratings suitable to the loads.
- H. Fusible Switches: Heavy duty switches, with positive pressure type reinforced fuse clips and fuses of classes and current ratings indicated.
  - 1. Non-fused disconnect switches may be used provided that the equipment nameplate makes no reference to "maximum fuse size", "maximum overcurrent protection", "fuse size" or "MFS".

- I. Provide disconnect switches having the capability to have auxiliary contacts mounted as required.
- J. Disconnects shall be finished in manufacturer's standard gray finish unless otherwise noted on drawings.
- K. Disconnect switches specified as being an integral part of a piece of equipment shall come factory installed and wired.

## **2.2 FUSES**

- A. Acceptable Manufacturers
  - 1. Bussman Division of Cooper Industries, Inc.
  - 2. Shawmut Division of Gould, Inc.
  - 3. Littlefuse, Inc.
- B. All fuses shall be Class RK1, time delay type.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and surfaces to receive disconnect switches for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 ELECTRICAL REQUIREMENTS - GENERAL**

- A. While Electrical Trade is responsible for proper direction of rotation of all 3-phase equipment, it is the duty of the HVAC Trade to confirm that all 3-phase equipment is rotating in the proper direction during start-up of equipment and to inform the Electrical Trade of any equipment that is not rotating in the proper direction.
- B. In general, rigid conduit or tubing shall be used, but equipment that requires movement or that would transmit vibration to conduit shall be wired with flexible (liquid tight) steel conduit not exceeding 18" in length.
- C. All equipment shall be grounded with a green-covered ground wire run inside the conduit and connected to equipment frame on one end and to grounding system on the other end.
- D. All electrical work required in Division 23 shall conform to all applicable requirements of Division 26 of these Specifications, and shall comply with the latest edition of the National Electric Code.
- E. The HVAC Trade shall assign all low-voltage and line-voltage Electrical Control Work required under this Contract to the Automatic Temperature Control Subcontractor, who shall perform this work with qualified electricians employed by that Subcontractor.
- F. The HVAC Trade shall co-operate with the contractor for Electrical Work in making all necessary tests and in receiving, storing and setting all motor-driven equipment, electrical devices, and controls furnished and/or installed under these Contracts.

G. Single phase equipment controls and wiring shall be as follows:

1. HVAC Trade shall retain the services of an ATC Subcontractor, who shall furnish and install all control devices, such as motor sentinel switches, PE switches, thermostats, etc.
2. The Electrical Trade shall complete all power wiring and connections for single phase equipment, through the disconnect and/or the thermal cutouts and local control stations to the equipment as required.
3. The HVAC Trade will furnish a THERMAL OVERLOAD SWITCH for all single-phase motors except where units are furnished with built-in Thermal Protection, in which case he will furnish a single pole switch.

H. Three phase equipment controls and wiring shall be as follows:

1. The HVAC Trade shall furnish all combination motors starters; refer to Division 23 Section 230511 "Enclosed Motor Controllers for HVAC Equipment" for requirements. The Electrical Trade shall install all combination motor starters.
2. The HVAC Trade shall retain the services of an ATC Subcontractor, who shall furnish and install all control devices, such as EP and PE switches, thermostats, etc.
3. The ATC Subcontractor shall furnish and install all controls and control wiring from control devices to motor starters and contactors and between control devices.
4. The Electrical Trade shall complete all electrical connections through the disconnect, starter and motor terminals of all three-phase equipment. He shall be responsible for all power wiring and connections.

### **3.3 CONTROL WIRING INSTALLATION**

- A. Install wiring between enclosed controllers according to Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices where applicable.
1. Connect selector switches to bypass only manual control and automatic control devices that have no safety functions when switch is in hand position.
  2. Connect selector switches in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high temperature cutouts, and motor overload protectors.

### **3.4 CONNECTIONS**

- A. Conduit installation requirements are specified in other Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26.

### **3.5 DISCONNECT SWITCHES**

- A. For each HVAC equipment item being furnished on the project the HVAC Trade shall:
1. Review/coordinate with the equipment manufacturer to determine whether a disconnect switch will be furnished with it.
  2. Review the electrical drawings and/or coordinate with the Electrical Trade to determine whether the Electrical Trade will be providing a disconnect switch for the equipment item.

- B. A disconnect switch shall be provided for each HVAC equipment item that has a 1-phase or 3-phase power connection. The HVAC Trade shall provide a disconnect switch for an equipment item unless one of the following occur:
  - 1. The equipment manufacturer is required to furnish or provide a disconnect switch or a combination motor starter/disconnect for the equipment item.
  - 2. The electrical drawings require the Electrical Trade to provide a disconnect switch for the equipment item.
- C. Mount disconnect switch to the equipment item it serves. If a disconnect switch cannot be mounted to the equipment item it serves or the drawings indicate the disconnect switch to be mounted in a different location, mount switch in a location within 50 feet and within eyesight of the equipment item. Provide miscellaneous steel as required to mount the disconnect switch.
  - 1. Bolt disconnect switches to equipment casing or to wall, or mount on free-standing lightweight structural steel channels and bolted to floor, equipment rails or roof curb.
  - 2. Structural steel channels, angle iron and other miscellaneous steel are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

### **3.6 FUSES**

- A. Fuses: Fuses shall be provided for each HVAC equipment item having power connection and requiring fuses. If fuses are not furnished with the HVAC equipment item, then the HVAC Trade shall provide all the necessary fuses for proper operation of the equipment and the electrical circuit.
  - 1. Install fuses in each fusible switch. Comply with requirements in Division 26.

### **3.7 IDENTIFICATION**

- A. Identify disconnect switches, components, and control wiring according to Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

### **3.8 DUCT MOUNTED SMOKE DETECTOR INSTALLATION**

- A. All duct mounted smoke detectors will be furnished by the Electrical Contractor. The HVAC Trade shall install all duct mounted smoke detectors furnished by the Electrical Trade under this project.
- B. The Electrical Trade will provide all power wiring for duct mounted smoke detectors.
- C. The HVAC Trade shall provide all control wiring from the smoke detector(s) auxiliary contacts to its (their) associated system supply and/or return fan(s) motor starter(s) for the purpose of de-energizing the fan motor when smoke is detected within the duct system.

### **3.9 PIPING AND DUCTWORK COORDINATION**

- A. The HVAC Trade shall not run ductwork or piping above switchboards or panelboards in accordance with the National Electric Code Article 384. Before ductwork or piping is installed coordinate the exact locations with the Electrical Trade. Failure to comply with this requirement shall be cause for the ductwork and piping to be removed and relocated at no additional cost to the Owner.

## **END OF SECTION 23 0510**

## **SECTION 23 0511 - ENCLOSED MOTOR CONTROLLERS FOR HVAC EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Across-the-line, enclosed magnetic-type motor controllers.

#### **1.3 DEFINITIONS**

- A. CPT: Control power transformer.
- B. MCCB: Molded case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon controlled rectifier.

#### **1.4 SUBMITTALS**

- A. Product Data:
  - 1. For each type of across-the-line, magnetic controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes. Also include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following
    - a. Each installed unit's type and details.
    - b. Nameplate legends.
    - c. Short circuit current rating of integrated unit.
    - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
    - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
    - f. Wiring Diagrams: Power, signal, and control wiring.



- B. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section 01 7823 "Operation and Maintenance Data," include the following:
  - 1. Routine maintenance requirements for enclosed controllers and all installed components.
  - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

## **1.5 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Source Limitations: Obtain enclosed controllers and disconnect switches of a single type through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- D. Testing Agency Qualifications: Member Company of NETA or an NRTL.
  - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- E. Comply with NFPA 70.
- F. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside equipment; install electric heating of sufficient wattage to prevent condensation.

## **1.7 COORDINATION**

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

## 1.8 PROJECT CONDITIONS

- A. Environmental Limitations - rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than -22°F and not exceeding 104°F.
  2. Altitude: Not exceeding 6,600 feet.

## PART 2 - PRODUCTS

### 2.1 ACROSS-THE-LINE ENCLOSED MOTOR CONTROLLERS

- A. Acceptable Manufacturers
1. Cerus
  2. Eaton
  3. General Electric
  4. Square D
  5. Furnas
  6. Cutler-Hammer
  7. Allen-Bradley
- B. Combination Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated; and disconnect switch.
1. Control Circuit: 120-volt, single-phase power; obtained from an integral control power transformer with sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. The control circuit transformer shall have dual primary fusing and a fuse in a hot secondary leg, and one normally open auxiliary contact.
  2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
  3. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.
  4. Accessories: The following devices shall be factory installed in controller enclosure, unless otherwise indicated.
    - a. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
      - 1) Each combination magnetic controller that serves equipment specified or scheduled to be manually controlled shall be provided with a START-STOP push-button station.
      - 2) Each combination magnetic controller that serves equipment specified or scheduled to be automatically controlled shall be provided with a HAND-OFF-AUTO selector switch.
      - 3) Each combination magnetic controller shall be provided with red 'RUN' and green 'STOP' indicating lights.

- b. Control Relays:
  - 1) Provide an auxiliary relay for control of associated equipment.
  - 2) Provide an adjustable time-delay relay to eliminate nuisance tripping when momentary loss of power occurs.
- c. Phase Failure and under voltage relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable under voltage setting.
- d. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- e. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- f. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
- g. Terminals for connecting power factor correction capacitors to the line side or load side of overload relays.
- h. Spare control wiring terminal blocks, quantity as indicated; unwired or wired.

C. Enclosures

- 1. Description: Flush or surface mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
  - a. Indoor Mechanical Equipment Room, Locations: NEMA 250, Type 12.
  - b. Outdoor Locations: NEMA 250, Type 4X, stainless steel.

D. Factory Finishes

- 1. Finish: Manufacturer's standard paint applied to factory assembled and tested enclosed controllers before shipping.

E. Application - the HVAC Trade shall furnish properly-sized across-the-line, magnetic controller for all 3-phase motors provided under Division 23 to include the following:

- 1. Supply fans and return/exhaust fans for air handling units installed indoors.
- 2. Supply fans and return/exhaust fans for air handling units installed outdoors.
- 3. Centrifugal pumps.

F. For enclosed magnetic controllers with external control voltages, furnish an auxiliary contact on the disconnect switch to disconnect the external voltage source when the disconnect switch is off.

G. All safety devices shall be wired so that they stop the motor with the Hand-Off-Auto switch in the Hand as well as the Auto position. This will normally mean breaking the common wire from the Hand-Off-Auto switch to the starter's holding coil through the safety devices.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 ENCLOSED CONTROLLER APPLICATIONS**

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.
- C. Furnish an enclosed controller for each HVAC equipment item provided on the project that will operate on 3-phase power to the Electrical Trade. The Electrical trade shall mount and wire each enclosed controller.
  - 1. Enclosed controllers are not required for the following:
    - a. HVAC equipment that is scheduled, noted, or indicated to be provided with a variable frequency motor controller.
    - b. HVAC equipment that is scheduled, noted, or indicated to operate on 1-phase power.
    - c. HVAC equipment that is furnished with an integral enclosed controller from the factory.

### **3.3 INSTALLATION**

- A. Mount enclosed controllers as follows:
  - 1. Wall Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 0529 "Hangers and Supports for Electrical Systems."
  - 2. Pad Mounted or Floor Mounted Controllers: Mount on a free-standing structural frame complying with Division 23 Section 23 0529 "Hangers and Supports for HVAC" and constructed of lightweight structural steel channels. Bolt free-standing structural frame to equipment pad or to floor.
  - 3. Roof Mounted Controllers: Mount on structural frame complying with Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" and constructed of lightweight structural-steel channels. Bolt structural frame to roof curb.
- B. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- E. Install, connect, and fuse thermal-protector relays furnished with motor-driven equipment.

- F. Install power factor correction capacitors. Connect to the **line or load** side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
- G. Comply with NECA 1.
- H. While Electrical Trade is responsible for proper direction of rotation of all 3- phase equipment, it is the duty of the HVAC Trade to confirm that all 3-phase equipment is rotating in the proper direction during start-up of equipment and to inform the Electrical Trade of any equipment that is not rotating in the proper direction.
- I. Equipment delivered with enclosures that are inadequate for the installed location shall be equipped with special enclosures that suit the conditions of the installed location by the HVAC Contractor furnishing the equipment.
- J. Controls and wiring for enclosed motor controllers furnished on the project shall be as follows:
  - 1. The HVAC Trade shall furnish all enclosed motor controllers. The Electrical Trade shall install all enclosed motor controllers.
  - 2. The HVAC Trade shall retain the services of an ATC Subcontractor, who shall furnish and install all control devices, such as EP and PE switches, thermostats, etc.
  - 3. The ATC Subcontractor shall furnish and install all controls and control wiring from control devices to enclosed motor controllers and contactors and between control devices.
  - 4. The Electrical Trade shall complete all electrical connections through the disconnect, enclosed motor controller and motor terminals of all three-phase equipment. He shall be responsible for all power wiring and connections.

### **3.4 IDENTIFICATION**

- A. Identify enclosed motor controllers according to Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

### **3.5 FIELD QUALITY CONTROL**

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each enclosed motor controller element, bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Manufacturer's Field Service - engage a factory authorized service representative to perform the following:
  - 1. Inspect enclosed motor controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
  - 2. Assist in field testing of equipment including pretesting and adjusting of enclosed motor controllers.
  - 3. Report results in writing.
- C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

### **3.6 ADJUSTING**

- A. Set field adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

### **3.7 PROTECTION**

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

### **3.8 DEMONSTRATION**

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed motor controllers. Refer to Division 01.

**END OF SECTION 23 0511**

## **SECTION 23 0512 - VARIABLE FREQUENCY MOTOR CONTROLLERS FOR HVAC EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. This section includes separately enclosed, pre-assembled, combination variable frequency motor controllers (VFCs), rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

#### **1.3 DEFINITIONS**

- A. BAS: Building automation system.
- B. CPT: Control power transformer.
- C. EMI: Electromagnetic interference.
- D. IGBT: Insulated gate bipolar transistor.
- E. LAN: Local area network.
- F. LED: Light emitting diode.
- G. MCP: Motor circuit protector.
- H. NC: Normally closed.
- I. NO: Normally open.
- J. OCPD: Overcurrent protective device.
- K. PCC: Point of common coupling.
- L. PID: Control action, proportional plus integral plus derivative.
- M. PWM: Pulse width modulated.
- N. RFI: Radio frequency interference.
- O. TDD: Total demand (harmonic current) distortion.
- P. THD (V): Total harmonic voltage demand.
- Q. VFC: Variable frequency motor controller.

#### **1.4 SUBMITTALS**

- A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories. Also, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
  - 1. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
- B. Product Certificates: For each VFC, from manufacturer.
- C. Operation and Maintenance Data: For VFCs to include in operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
  - 1. Manufacturer's written instructions for testing, adjusting, and programming overload setting, timers, controls, and status and alarm points related to the VFC.

#### **1.5 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. Comply with NFPA 70.

#### **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Comply with the requirements described in Division 01.

#### **1.7 PROJECT CONDITIONS**

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than 14°F and not exceeding 104°F.
  - 2. Ambient Storage Temperature: Not less than -4°F and not exceeding 140°F.
  - 3. Humidity: Less than 95 percent (non-condensing).
  - 4. Altitude: Not exceeding 3,300 feet.
- B. Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

#### **1.8 COORDINATION**

- A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
  - 1. Torque, speed, and horsepower requirements of the load.
  - 2. Ratings and characteristics of supply circuit and required control sequence.
  - 3. Ambient and environmental conditions of installation location.



- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- C. 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 VFCs that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five (5) years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURED VARIABLE FREQUENCY MOTOR CONTROLLERS**

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - 1. ABB
  - 2. Danfoss Inc.; Danfoss Drives Division
  - 3. Eaton
  - 4. Toshiba International Corporation
  - 5. Yaskawa Electric America, Inc; Drives Division
- B. Description: Enclosed variable frequency motor controllers shall be suitable for operation at the current, voltage, and horsepower of the motor being controlled as indicated in the schedules on the Drawings. Conform to requirements of NEMA ICS 3.1.
  - 1. Motors shall be inverter duty rated, per NEMA MG1 parts 30 and 31, for motor-drive compatibility.
- C. Ratings
  - 1. Input Voltage: VFCs must operate, without fault or failure, when voltage varies plus or minus 10% from rating.
  - 2. Input Frequency: VFCs must operate, without fault or failure, when frequency varies plus or minus 5% from rating.
  - 3. Displacement Power Factor: 0.98 over entire range of operating speed and load.
  - 4. Operating Ambient Temperature: VFCs must operate, without fault or failure, at ambient temperature conditions ranging from 14°F to 104°F. Above 104°F, the maximum output current shall be de-rated not more than 1% for every additional 1°C up to 50°C (122°F).
  - 5. Operating Ambient Humidity: VFCs must operate, without fault or failure, at ambient relative humidity conditions ranging from 5% to 95% non-condensing.
  - 6. Altitude: Up to 3,300-feet above sea level. At sites over 3300-feet above sea level, the maximum output current shall be de-rated not more than 1% for every additional 330-feet of elevation.
  - 7. Minimum Efficiency: 96% at half speed; 98% at full speed.
  - 8. Continuous Output Current, Variable Torque: 100% starting torque shall be available from 0.5 Hz. to 60 Hz.
  - 9. Short Term Overload Capacity, Variable Torque: 110% of rated FLA (Full Load Amps) for 60 seconds.

10. Peak Overload Capacity, Variable Torque: 135% of rated FLA (Full Load Amps) instantaneously.
11. Output Acceleration Time: Adjustable from 0 to 1800 seconds
12. Output Deceleration Time: Adjustable from 0 to 1800 seconds
13. The VFC must meet the requirements for Radio Frequency Interference (RFI) above 7 MHz as specified by FCC regulations, part 15, subpart J, Class A devices.
14. VFCs must have a minimum short circuit rating of 65K amps RMS (100K amps RMS with a DC bus reactor) without additional input fusing.

D. Design

1. VFCs shall employ microprocessor-based inverter logic, isolated from all power circuits.
2. VFCs shall include surface mount technology with protective coating.
3. VFCs shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
  - a. Input Section:
    - 1) VFC input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid-state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection.
  - b. Intermediate Section:
    - 1) DC bus as a supply to the VFC output Section shall maintain a fixed voltage with filtering and short circuit protection.
    - 2) DC bus shall be interfaced with the VFC diagnostic logic circuit, for continuous monitoring and protection of the power components.
    - 3) VFCs 40 HP and larger shall include a DC bus reactor to minimize reflected harmonics.
  - c. Output Section
    - 1) Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
    - 2) The VFC shall employ PWM sine coded output technology to power the motor.
  - d. VFCs must be selected for operation at carrier frequencies at or above 500 Hz without derating to satisfy the conditions for current, voltage, and horsepower as indicated on the equipment schedule.
  - e. VFCs shall have an adjustable carrier frequency. The carrier frequency shall have a minimum of six settings to allow adjustment in the field.
  - f. Building Automation System (BAS) Interface: VFCs shall have embedded BAS protocols for network communications or be furnished with an interface device accessible via a RS-422/485 communication port to provide one **or more** of the following:
    - 1) A fully BACNet compatible VFC.
  - g. VFCs shall have a quick disconnect, removable control I/O terminal block to simplify control wiring procedures.
  - h. Analog Inputs: VFCs shall include two independent analog inputs as described below. Either input shall respond to a programmable bias and gain.
    - 1) One shall be 0-10 VDC.
    - 2) The other shall be programmable for either 0-10 VDC or 4-20 mA.

- i. Digital Inputs: VFCs shall include a minimum of six multi-function digital input terminals, capable of being programmed to determine the function on a change of state. These terminals shall provide up to 30 functions, including, but not limited to:
  - 1) Remote/Local operation selection
  - 2) Detection of external fault condition
  - 3) Remote Reset
  - 4) Multi-step speed commands
  - 5) Run permissive
  - 6) Floating control
- j. Analog Outputs: VFCs shall include two 0-10 VDC or 4-20 mA analog outputs for monitoring or "speed tracking" the VFCS. The analog output signal will be proportional to output frequency, output current, output power, PI (Proportional & Integral control) feedback or DC bus voltage.
- k. VFCs shall provide terminals for remote input contact closure, to allow starting in the automatic mode.
- l. VFCs shall include a minimum three form "C" output relay contacts each capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 5A at 120 VAC and shall provide up to 18 functions, including, but not limited to:
  - 1) Speed agree detection.
  - 2) Low and high frequency detection.
  - 3) Missing frequency reference detection.
  - 4) Over torque/Under torque detection
  - 5) Drive Running
  - 6) Drive Faulted
- m. Power Loss Ride Through: VFCs shall include a power loss ride through of 2 seconds.
- n. VFCs shall have DC injection braking capability, to prevent fan "wind milling" at start or stop, adjustable, current limited.
- o. VFCs shall include diagnostic fault indication in selected language, last 10 faults storage and heatsink cooling fan operating hours.
- p. VFCs shall have a digital operator with program copy and storage functions to simplify set up of multiple drives. The digital operator shall be interchangeable for all drive ratings.
- q. User Control Panel (Keypad): VFCs shall include a front mounted, sealed keypad operator, with an English language (or one of 6 additional international languages) illuminated LCD display. The operator will provide complete programming, program copying, operating, monitoring, and diagnostic capability. Keys provided shall include industry standard commands for Hand, Off, and Auto functions. VFCs plain language display shall be viewed in an easy-to-read illuminated LCD with International language selectability and shall provide readouts of the following:
  - 1) Output frequency in hertz
  - 2) PI feedback in percent
  - 3) Output voltage in volts
  - 4) Output current in amps
  - 5) Output power in kilowatts
  - 6) D.C. bus voltage in volts
  - 7) Interface terminal status
  - 8) Heatsink temperature

- 9) Fault conditions.
- 10) The VFC unit shall include the following meters to estimate use of energy:
  - a) Elapsed Time Meter
  - b) Kilowatt Meter
  - c) Kilowatt Hour Meter
- r. PID Control: VFCs shall include PI control logic, to provide closed loop setpoint control capability, from a feedback signal, eliminating the need for closed loop output signals from a building automation system. The PI controller shall have a differential feedback capability for closed loop control of fans and pumps for pressure, flow or temperature regulation in response to dual feedback signals.
- s. Sleep Function: An energy saving sleep function shall be available in both open loop (follower mode) and closed loop (PI) control, providing significant energy savings while minimizing operating hours on driven equipment. When the sleep function senses a minimal deviation of a feedback signal from setpoint, or low demand in open loop control, the system shall react by stopping the driven equipment. Upon receiving an increase in speed command signal deviation, the drive and equipment shall resume normal operation.
- t. VFCs shall include the following motor control features:
  - 1) 14 preset and 1 custom volts per hertz pattern. These shall include scaler and vector modes of motor control. Volts per hertz patterns shall also include linear and squared shapes.
  - 2) Energy optimization.
  - 3) IR compensation.
  - 4) Slip compensation
  - 5) Critical frequency rejection capability. A minimum of 3 selectable, adjustable dead bands shall be provided.
  - 6) Motor preheat function: VFCs shall have a motor preheat function to prevent moisture accumulation in an idle motor.
- u. VFCs shall include the following preprogrammed protection circuits:
  - 1) Overcurrent.
  - 2) Short circuit.
  - 3) Overvoltage
  - 4) Under voltage
  - 5) Input phase loss
  - 6) Output device (IGBT) over temperature
  - 7) Current limit regulator adjustable from 30% to 200% of rated full load current of the VFC
  - 8) Electronic motor overload (UL 508C approved)
- v. VFCs shall include the following programmable fault functions for protection:
  - 1) Electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL.
  - 2) Loss of analog input signal protection, with a selectable response strategy including speed default to a percent of the most recent speed.
  - 3) Loss of panel
  - 4) External fault. VFCs shall include at least one external fault input, which shall be programmable for a normally open or normally closed contact. This terminal or terminals shall be used for connection of firestats, low temperature thermostats, high pressure limits or similar safety devices.

- 5) Stall prevention
- 6) Underload
- 7) Motor phase loss
- 8) Ground fault

w. VFCs shall also include the following additional program functions:

- 1) Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
- 2) Ability to close fault contact after the completion of all fault restart attempts.
- 3) "S" curve soft start capability.
- 4) Bi-directional "Speed search" capability, in order to start a rotating load.
- 5) Heatsink over temperature speed fold back capability
- 6) Terminal status indication.
- 7) Program copy and storage in a removable digital operator.
- 8) Motor pre-heat capability
- 9) Input signal or serial communication loss detection and response strategy.
- 10) Anti "wind-milling" function capability.
- 11) Automatic energy saving function.
- 12) Under torque/Over torque Detection.
- 13) Preset speeds

x. VFCs shall include factory settings for all parameters, and the capability for those settings to be reset.

y. VFCs shall include user parameter initialization capability to re-establish project specific parameters

z. The VFC shall include the capability to adjust the following functions, while the VFC is running:

- 1) Speed command input.
- 2) Acceleration adjustment from 0 to 1800 seconds.
- 3) Deceleration adjustment from 0 to 1800 seconds.
- 4) Select from 5 preset speeds.
- 5) Analog monitor display.
- 6) Removal of digital operator.

#### E. VFC Enclosures

1. NEMA 250, to comply with environmental conditions at installed location. All standard and additional features shall be included in a single enclosure with a UL certification label.
  - a. Dry and Clean Indoor Locations: NEMA 1 extended enclosure, to house additional equipment within the VFC enclosure for VFCs not requiring Bypass.
  - b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 12 FVFF (Forced Ventilation inlet Filter and outlet Filter) enclosures with filters and blower.
  - c. Kitchen Areas, Washdown Areas, and other Wet or Damp Indoor Locations: NEMA 4X enclosure.
  - d. Outdoor Locations: NEMA 3R enclosure.
2. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

F. Additional Features

1. Input Disconnect: A VFC Input MCP circuit breaker/disconnect shall be provided.
2. Miscellaneous Accessories:
  - a. Miscellaneous control accessories such as relays, motor overloads and time delays shall be furnished integral with the VFC in order to provide proper operation and control of the VFC in accordance with the sequence of operation described in Division 23 Section 23 0993 "Sequence of Operation for HVAC Control."
  - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
    - 1) Each VFC that serves equipment specified or scheduled to be manually controlled shall be provided with a START-STOP push-button station.
    - 2) Each VFC that serves equipment specified or scheduled to be automatically controlled shall be provided with a HAND-OFF-AUTO selector switch.
    - 3) Each VFC shall be provided with red 'RUN' and green 'STOP' indicating lights.
3. Engraved Cabinet Nameplate: An engraved cabinet nameplate shall be provided for each VFC.
4. Three-Contactor Manual Bypass: The bypass shall be provided for each fan indicated to be provided with a VFC and shall be provided for each pump not designed in an operating/stand-by mode indicated to be provided with a VFC. The VFC and bypass components shall be mounted inside a common NEMA rated enclosure, fully pre-wired, and ready for installation as a single UL listed device. Refer to the "Enclosure" paragraph above for the enclosure required for each particular installation. The bypass shall include the following:
  - a. Input, output, and bypass contactors, to disconnect power to the VFC, when the motor is running in the bypass mode.
  - b. 120 VAC control transformer, with fused primary.
  - c. Magnetic overload relay, to protect the motor while operating in the bypass mode.
  - d. Circuit breaker/disconnect switch, with a pad-lockable through-the-door handle mechanism.
  - e. Control and safety circuit terminal strip.
  - f. Drive/Bypass selector switch, Hand/Off/Auto selector switch, Normal/Test selector switch
  - g. Switch selectable auto transfer to bypass and remote transfer functions.
  - h. Pilot lights (22 mm LEDs) for "Control Power ", "Drive Fault", "Drive Run", "Bypass Run", "OL/Safety Fault".
  - i. Normal/Test selector switch, shall allow testing and adjustment of the VFC, while the motor is running in the bypass mode.
  - j. Hand/Off/Auto selector switch shall provide the following operation:
    - 1) Hand Position - The drive is given a start command; operation is via the local speed input (digital operator or speed pot.). If in bypass mode, the motor is running.
    - 2) Off Position - The start command is removed, all speed inputs are ignored, power is still applied to the drive. If in bypass mode, the motor is stopped.
    - 3) Auto Position - The drive is enabled to receive a start command and speed input from a building automation system. If in bypass mode, the motor start/stop is controlled by the building automation system
  - k. Annunciation contacts for drive run, drive fault, bypass run and motor OL/safety fault.
  - l. Damper control circuit with end of travel feedback capability.
  - m. VFC operator/keypad selection, LCD or LED types.
  - n. H/O/A control panel selection, Touch pad or rotary switch types.

5. Line Reactors: 3% Line reactors shall be provided on the input side of the drive for harmonic suppression.
6. Output Reactors: Output reactors shall be provided on the output side of the drive for motor protection in long motor lead length situations per the following:
  - a. 3% Output Reactor @ 208/240 VAC for distances over 300-feet.
  - b. 3% Output Reactor @ 460/480 VAC for distances over 50-feet
7. Electric Heater: An electric space heater with normally-closed auxiliary contacts shall be furnished integral with each VFC enclosure installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings in order to control internal temperature, mitigate internal condensation, and maintain proper operation of the VFC during periods when ambient temperature is below 55°F. Power for the space heater shall be obtained from an integral control/stepdown power transformer.
8. Ventilation Fan: A ventilation fan shall be furnished integral with each VFC enclosure installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings in order to control internal temperature, control internal humidity, and maintain proper operation of the VFC during periods when ambient temperature is above 55°F. In addition, the enclosure shall be furnished with integral composite or stainless steel intake and exhaust grilles and filters. Power for the ventilation fan shall be obtained from an integral control/stepdown power transformer.
9. RFI (Radio Frequency Interference) Filters: RFI filters shall be provided to further attenuate possible VFC generated noise.
10. Pressure Transducer: A pressure transducer (3 to 15 PSI input = 0 to 10 V DC output) shall be provided to convert a pneumatic signal into a VFC Speed Command Input.
11. Output Motor Protection Filter: An output motor protection (dv/dt) filter shall be provided for long motor lead length installations as follows:
  - a. Output Filter @ 208/240 VAC for distances over 500-feet.
  - b. Output Filter @ 460/480 VAC for distances over 200-feet
12. Analog Output: An additional analog output (4-20 mA) shall be provided to make available two analog current outputs.
13. Remote Digital Operator: A remote digital operator, with keypad and display, shall be provided to control and monitor the VFC from a remote location.
14. Analog Meter: An analog meter shall be provided in addition to the digital keypad monitoring capabilities.
15. PC Software Cable: A PC software and cable shall be provided for parameter upload/download/graphing.

## 2.2 SOURCE QUALITY CONTROL

- A. In-circuit testing of all printed circuit boards shall be conducted, to insure the proper mounting and correct value of all components.
- B. All printed circuit boards shall be burned in for 96 hours, at 185°F.
- C. Final printed circuit board assemblies shall be functionally tested, via computerized test equipment. All tests and acceptance criteria shall be preprogrammed. All test results shall be stored as detailed quality assurance data.
- D. All fully assembled controls shall be functionally tested, with fully loaded induction motors. The combined test data shall then be analyzed, to insure adherence to quality assurance specifications.
- E. Inspect and production test, under load, each completed VFC assembly.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Wall mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural steel channels bolted to wall. For controllers not mounted on walls, provide freestanding racks complying with Division 26.
- C. Floor mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03. Ensure disconnect operating handles are installed not higher than 79 inches above finished floor unless otherwise indicated.
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Roof Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated. Bolt units to curbs or mount on freestanding, lightweight, structural steel channels or angle iron bolted to curbs. Seal roof penetrations after raceways are installed.
  - 1. Curbs and roof penetrations are specified in Division 07.
  - 2. Structural steel channels are specified in Division 23 Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- F. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26.



- G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- I. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."
  - 1. Identify field installed conductors, interconnecting wiring, and components.
  - 2. Label each VFC with engraved nameplate.
  - 3. Label each enclosure mounted control and pilot device.

### **3.4 CONTROL WIRING INSTALLATION**

- A. Install wiring between VFCs and remote devices and facility's building automation system. Comply with requirements in Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable. Refer to Division 23 Section 23 0993 "Sequence of Operation for HVAC Control" for requirements.

### **3.5 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. Acceptance Testing Preparation
  - 1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- C. Tests and Inspections
  - 1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
  - 2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
  - 3. Test continuity of each circuit.
  - 4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Engineer before starting the motor(s).
  - 5. Test each motor for proper phase rotation.
  - 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- 8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. VFCs will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

### **3.6 STARTUP SERVICE**

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

### **3.7 ADJUSTING**

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Set the taps on reduced voltage autotransformer controllers.
- D. Set field adjustable pressure switches.

### **3.8 DEMONSTRATION**

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

**END OF SECTION 23 0512**

## **SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 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.

#### **1.3 COORDINATION**

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
  - 1. Motor controllers.
  - 2. Torque, speed, and horsepower requirements of the load.
  - 3. Ratings and characteristics of supply circuit and required control sequence.
  - 4. Ambient and environmental conditions of installation location.

### **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. Efficiency: NEMA Premium efficiency, as defined in NEMA MG 1.
  - 1. Electric motors shall comply with the requirements of the Energy Policy Act of 1992.
  - 2. Motors that are single-speed, polyphase, 1-500 horsepower, 2, 4, and 6 pole, squirrel cage induction type, NEMA Design A or B, continuous rated shall be NEMA Premium efficiency electric motors.
    - a. NEMA Premium efficiency electric motors must meet or exceed the nominal energy efficiency levels presented below.
      - 1) The NEMA Premium efficiency levels are contained in NEMA Standards Publication MG 1- 2006, in Tables 12-12 and 12-13, respectively.

## **2.2 MOTOR CHARACTERISTICS**

- A. Duty: Continuous duty at ambient temperature of 104°F and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

## **2.3 POLYPHASE MOTORS**

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Service Factor: 1.15.
- C. Rotor: Random-wound, squirrel cage.
- D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- E. Temperature Rise: Match insulation requirements.
- F. Insulation: Class F.
- G. 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.
- H. 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 Variable Frequency Controllers: Ratings, characteristics, and features of motors shall be coordinated with the variable frequency controller manufacturer. Each motor shall be compatible with the variable frequency controller driving it.
  - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
  - 2. Energy and Premium Efficient Motors: Class B temperature rise; Class F insulation.
  - 3. Inverter Duty Motors: Class F temperature rise; Class H insulation.
  - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
  - 5. Shaft Grounding Ring: Provide for all motors 5 hp and greater.
    - a. General: Protects motor bearings from Electrical Discharge Machining (EDM), by discharging shaft currents to ground, via motor frame.
    - b. Type: Circumferential, with aluminum frame, and frictionless, conductive microfiber shaft brushes
    - c. Mounting Location: Drive end or non-drive end of motor; Internal to the motor frame; Installed by motor manufacturer
    - d. Maintenance Required: None
    - e. Service Life: Designed to last for service life of motor
    - f. RPM Limitation: None
    - g. Manufacturer: Aegis SGR, or approved equal

## **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. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- C. Motors 1/20 HP and Smaller: Shaded-pole type.
- D. 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.
- E. Electronic Commutation (EC) Motors: Each EC motor shall be specifically designed for its particular application. EC motors shall be permanently lubricated, shall have heavy-duty ball bearings to match the load, and shall be prewired to the specific voltage and phase. EC motors shall have internal motor circuitry to convert AC power supplied to DC power in order to properly operate the motor. EC motors shall be capable of having their speed controlled down to 20% of full speed (80% turndown). EC motor speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Each EC motor shall have a minimum efficiency of 85% at all speeds.

## **PART 3 - EXECUTION (Not Applicable)**

**END OF SECTION 23 0513**

## **SECTION 23 0519 - METERS AND GAUGES FOR HVAC 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes
  - 1. Liquid-in-glass thermometers.
  - 2. Thermowells.
  - 3. Dial-type pressure gauges.
  - 4. Gauge attachments.
  - 5. Test plugs.
  - 6. Test plug kits.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
  - 1. Liquid-in-glass thermometers.
  - 2. Thermowells.
  - 3. Dial-type pressure gauges.
  - 4. Gauge attachments.
  - 5. Test plugs.
  - 6. Test plug kits.
- B. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

### **PART 2 - PRODUCTS**

#### **2.1 LIQUID-IN-GLASS THERMOMETERS**

- A. Plastic-Case, Liquid-in-Glass Thermometers
  - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. Ashcroft Inc.
    - b. Ernst Flow Industries
    - c. Miljoco Corporation

- d. Palmer Wahl Instrumentation Group
  - e. Terrice, H. O. Company
  - f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  - g. Weiss Instruments, Inc.
  - h. WIKA Instrument Corporation - USA.
  - i. Winters Instruments - U.S.
- 2. Standard: ASME B40.200.
  - 3. Case: Plastic 9-inch nominal size unless otherwise indicated.
  - 4. Case Form: Adjustable angle unless otherwise indicated.
  - 5. Tube: Glass with magnifying lens and blue or red organic liquid.
  - 6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in degree F.
  - 7. Window: Glass or plastic.
  - 8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
- a. Design for Thermowell Installation: Bare stem.
- 9. Connector: 1-1/4 inches with ASME B1.1 screw threads.
  - 10. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

## 2.2 THERMOWELLS

### A. Thermowells

- 1. Standard: ASME B40.200.
- 2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
- 3. Material for Use with Copper Tubing: CNR (copper nickel 90-10) or CUNI (copper nickel 70-30).
- 4. Material for Use with Steel Piping: CRES (corrosion-resistant steel) or CSA (steel).
- 5. Type: Stepped shank unless straight or tapered shank is indicated.
- 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
- 7. Internal Threads: 1/2, 3/4, and 1 inch with ASME B1.1 screw threads.
- 8. Bore: Diameter required to match thermometer bulb or stem.
- 9. Insertion Length: Length required to match thermometer bulb or stem.
- 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
- 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

### B. Heat-Transfer Medium: Mixture of graphite and glycerin.

## 2.3 PRESSURE GAUGES

### A. Direct Mounted, Plastic Case, Dial-Type Pressure Gauges

- 1. Manufacturers- subject to compliance with requirements, provide products by one of the following:
  - a. Ashcroft Inc.
  - b. Ernst Flow Industries
  - c. Miljoco Corporation

- d. Palmer Wahl Instrumentation Group
  - e. Terrice, H. O. Company
  - f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  - g. Weiss Instruments, Inc.
  - h. WIKA Instrument Corporation - USA
  - i. Winters Instruments - U.S.
- 2. Standard: ASME B40.100.
  - 3. Case: Sealed type; plastic; 4-1/2-inch nominal diameter.
  - 4. Pressure Element Assembly: Bourdon tube unless otherwise indicated.
  - 5. Pressure Connection: Brass, with ASME B1.20.1 pipe threads and bottom-outlet type.
  - 6. Movement: Mechanical, with link to pressure element and connection to pointer.
  - 7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi and kPa.
  - 8. Pointer: Dark colored metal.
  - 9. Window: Glass or plastic.
  - 10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

## **2.4 GAUGE ATTACHMENTS**

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball, brass needle, or stainless steel needle, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

## **2.5 TEST PLUGS**

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - 1. Flow Design, Inc.
  - 2. Miljoco Corporation
  - 3. Peterson Equipment Co., Inc.
  - 4. Sisco Manufacturing Company, Inc.
  - 5. Terrice, H. O. Company
  - 6. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  - 7. Weiss Instruments, Inc.
- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200°F.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.



## **2.6 TEST PLUG KITS**

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - 1. Flow Design, Inc.
  - 2. Miljoco Corporation
  - 3. Peterson Equipment Co., Inc.
  - 4. Sisco Manufacturing Company, Inc.
  - 5. Trerice, H. O. Company
  - 6. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  - 7. Weiss Instruments, Inc.
- B. Furnish one test plug kit containing two thermometers, one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- C. Low Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 25° to 125°F.
- D. High Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0° to 220°F.
- E. Pressure Gauge: Small, Bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.
- F. Carrying Case: Metal or plastic, with formed instrument padding.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install direct mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
- G. Install valve and snubber in piping for each pressure gauge for fluids (except steam).
- H. Install test plugs in piping tees.

- I. Install thermometers in the following locations:
  - 1. Supply and return of the hydronic loop serving the building. Thermometers to be located in the Mechanical Room.
  - 2. Supply and return of the hydronic loop serving the geothermal wellfield. Thermometers to be located in the Mechanical room.
- J. Install pressure gauges in the following locations:
  - 1. Suction and discharge of each pump.

### **3.2 CONNECTIONS**

- A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

### **3.3 ADJUSTING**

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gauges to proper angle for best visibility.

### **3.4 THERMOMETER SCALE RANGE SCHEDULE**

- A. Scale Range for Condenser Water Piping: 0° to 100°F.

### **3.5 PRESSURE GAUGE SCALE RANGE SCHEDULE**

- A. Scale Range for Condenser Water Piping: 0 to 100 psi.

**END OF SECTION 23 0519**

## **SECTION 23 0523 - GENERAL - DUTY VALVES FOR HVAC 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Bronze ball valves.
  - 2. Iron, single flange butterfly valves.
  - 3. Iron, grooved-end butterfly valves.
  - 4. Bronze swing check valves.
  - 5. Iron swing check valves.
  - 6. Iron, grooved-end swing-check valves.
  - 7. Bronze gate valves.
  - 8. Iron gate valves.
  - 9. Bronze globe valves.
  - 10. Iron globe valves.
- B. Related Sections:
  - 1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
  - 2. Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

#### **1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Non-rising stem.
- E. OS&Y: Outside screw and yoke.
- F. RS: Rising stem.
- G. SWP: Steam working pressure.

## **1.4 SUBMITTALS**

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

1. Bronze ball valves.
2. Iron, single flange butterfly valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Bronze gate valves.
6. Iron gate valves.
7. Bronze globe valves.
8. Iron globe valves.

## **1.5 QUALITY ASSURANCE**

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

B. ASME Compliance:

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

## **1.6 DELIVERY, STORAGE, AND HANDLING**

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set gate and globe valves closed to prevent rattling.
4. Set ball valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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

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

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS FOR VALVES**

A. Refer to HVAC valve schedule articles for applications of valves.

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Hand lever: For quarter-turn valves NPS 6 (DN 150) and smaller.

E. Valves in Insulated Piping - with 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Threaded: With threads according to ASME B1.20.1.

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

## **2.2 BRONZE BALL VALVES**

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. American Valve, Inc.
  - b. Conbraco Industries, Inc.; Apollo Valves
  - c. Crane Co.; Crane Valve Group; Crane Valves
  - d. Hammond Valve
  - e. Milwaukee Valve Company
  - f. Nibco, Inc.
  - g. Red-White Valve Corporation
  - h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-110.
  - b. SWP Rating: 150 psig.
  - c. CWP Rating: 600 psig.
  - d. Body Design: Two piece.
  - e. Body Material: Bronze.
  - f. Ends: Threaded.
  - g. Seats: PTFE or TFE.
  - h. Stem: Bronze.
  - i. Ball: Chrome plated brass.
  - j. Port: Full.

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless steel Trim:

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

## 2.3 IRON, SINGLE FLANGE BUTTERFLY VALVES

A. 150 CWP, Iron, Single flange Butterfly Valves with EPDM Seat and Aluminum-Bronze or Stainless steel Disc:

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. Bray Controls; a division of Bray International
  - b. Conbraco Industries, Inc.; Apollo Valves
  - c. Crane Co.; Crane Valve Group; Jenkins Valves
  - d. Crane Co.; Crane Valve Group; Stockham Division
  - e. DeZurik Water Controls
  - f. Hammond Valve
  - g. Milwaukee Valve Company
  - h. Nibco, Inc.
  - i. Red-White Valve Corporation
  - j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-67, Type I.
  - b. CWP Rating: 150 psig.
  - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
  - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
  - e. Seat: EPDM.
  - f. Stem: One- or two-piece stainless steel.
  - g. Disc: Aluminum bronze or stainless steel.

## **2.4 BRONZE SWING CHECK VALVES**

### **A. Class 125, Bronze Swing Check Valves with Bronze Disc**

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

## **2.5 IRON SWING CHECK VALVES**

### **A. Class 125, Iron Swing Check Valves with Metal Seats**

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. Crane Co.; Crane Valve Group; Crane Valves
  - b. Crane Co.; Crane Valve Group; Jenkins Valves
  - c. Crane Co.; Crane Valve Group; Stockham Division
  - d. Hammond Valve
  - e. Milwaukee Valve Company
  - f. Nibco, Inc.
  - g. Red-White Valve Corporation
  - h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-71, Type I.
  - b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig.
  - c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig.
  - d. Body Design: Clear or full waterway.
  - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
  - f. Ends: Flanged.
  - g. Trim: Bronze.
  - h. Gasket: Asbestos free.

## 2.6 BRONZE GATE VALVES

### A. Class 125, RS Bronze Gate Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. American Valve, Inc.
  - b. Crane Co.; Crane Valve Group; Crane Valves
  - c. Crane Co.; Crane Valve Group; Jenkins Valves
  - d. Crane Co.; Crane Valve Group; Stockham Division
  - e. Hammond Valve
  - f. Milwaukee Valve Company
  - g. Nibco, Inc.
  - h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-80, Type 2.
  - b. CWP Rating: 200 psig.
  - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
  - d. Ends: **Threaded**
  - e. Stem: Bronze
  - f. Disc: Solid wedge; bronze
  - g. Packing: Asbestos free
  - h. Handwheel: Malleable iron

## 2.7 IRON GATE VALVES

### A. Class 125, OS&Y, Iron Gate Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. Crane Co.; Crane Valve Group; Crane Valves
  - b. Crane Co.; Crane Valve Group; Jenkins Valves
  - c. Crane Co.; Crane Valve Group; Stockham Division
  - d. Flo Fab Inc.
  - e. Hammond Valve
  - f. Milwaukee Valve Company
  - g. Nibco, Inc.
  - h. Red-White Valve Corporation
  - i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-70, Type I.
  - b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig.
  - c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig.
  - d. Body Material: ASTM A 126, gray iron with bolted bonnet.
  - e. Ends: Flanged
  - f. Trim: Bronze
  - g. Disc: Solid wedge
  - h. Packing and Gasket: Asbestos free



## 2.8 BRONZE GLOBE VALVES

### A. Class 125, Bronze Globe Valves with Bronze Disc

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. Crane Co.; Crane Valve Group; Crane Valves
  - b. Crane Co.; Crane Valve Group; Stockham Division
  - c. Hammond Valve
  - d. Milwaukee Valve Company
  - e. Nibco, Inc.
  - f. Red-White Valve Corporation
  - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-80, Type 1.
  - b. CWP Rating: 200 psig.
  - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
  - d. Ends: Threaded
  - e. Stem and Disc: Bronze
  - f. Packing: Asbestos free
  - g. Handwheel: Malleable iron

## 2.9 IRON GLOBE VALVES

### A. Class 125, Iron Globe Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - a. Crane Co.; Crane Valve Group; Crane Valves
  - b. Crane Co.; Crane Valve Group; Jenkins Valves
  - c. Crane Co.; Crane Valve Group; Stockham Division
  - d. Hammond Valve
  - e. Milwaukee Valve Company
  - f. Nibco, Inc.
  - g. Red-White Valve Corporation
  - h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
  - a. Standard: MSS SP-85, Type I.
  - b. CWP Rating: 200 psig.
  - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
  - d. Ends: Flanged.
  - e. Trim: Bronze.
  - f. Packing and Gasket: Asbestos free.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

### **3.2 VALVE INSTALLATION**

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow and as follows:
  - 1. Swing Check Valves: In horizontal position with hinge pin level.

### **3.3 ADJUSTING**

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

### **3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS**

- A. If valve applications are not indicated, use the following:
  - 1. Shutoff Service: Ball, butterfly, or gate valves.
  - 2. Butterfly Valve Dead-End Service: Single flange (lug) type.
  - 3. Throttling Service except Steam: Globe, ball, or butterfly valves.
  - 4. Pump-Discharge Check Valves:
    - a. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves with the following end connections:
  - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends.
  - 2. For Steel Piping, NPS 2-1/2 (DN 65) and Larger: Flanged ends.

### **3.5 CONDENSER WATER VALVE SCHEDULE**

- A. Pipe NPS 2 (DN 50) and Smaller:
  - 1. Bronze Valves: Threaded ends.
  - 2. Ball Valves: Two-piece, full port, bronze with bronze or stainless steel trim.
  - 3. Bronze Swing Check Valves: Class 125, bronze disc.
  - 4. Bronze Gate Valves: Class 125, rising-stem, bronze.
  - 5. Bronze Globe Valves: Class 125, bronze disc.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
  - 1. Iron Valves, NPS 2-1/2 and above (DN 65 to DN 100): Flanged or grooved ends.
  - 2. Iron, Single flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM or NBR seat, aluminum-bronze or stainless steel disc.
  - 3. Iron Swing Check Valves: Class 125, metal seats.
  - 4. Iron Gate Valves: Class 125, OS&Y.
  - 5. Iron Globe Valves: Class 125.

**END OF SECTION 23 0523**

## **SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 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.

#### **1.3 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."

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water. Design of pipe supports shall be provided through the HVAC trade by a civil or structural Engineer who is registered in the Commonwealth of Pennsylvania.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components. Design of equipment supports shall be provided through the HVAC trade by a civil or structural Engineer who is registered in the Commonwealth of Pennsylvania.

#### **1.5 SUBMITTALS**

- A. Product data for the following:
  - 1. Steel pipe hangers and supports.
  - 2. Thermal hanger shield inserts.
  - 3. Powder actuated fastener systems.
  - 4. Trapeze pipe hangers. Include Product Data for components.

5. Metal framing systems. Include Product Data for components.
6. Pipe stands. Include Product Data for components.
7. Equipment supports.

## **1.6 QUALITY ASSURANCE**

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

## **PART 2 - PRODUCTS**

### **2.1 STEEL PIPE HANGERS AND SUPPORTS**

- A. Description: MSS SP-58, Types 1 through 58, factory fabricated components. Refer to Part 3 "Hanger and Support Applications" article for where to use specific hanger and support types.
- B. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  1. AAA Technology & Specialties Co., Inc.
  2. B-Line Systems, Inc.; a division of Cooper Industries.
  3. ERICO/Michigan Hanger Company
  4. Globe Pipe Hanger Products, Inc.
  5. Grinnell Corporation
  6. GS Metals Corporation
  7. National Pipe Hanger Corporation
  8. PHD Manufacturing, Inc.
- C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

### **2.2 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.

### **2.3 METAL FRAMING SYSTEMS**

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

B. Manufacturers - subject to compliance with requirements, provide products by one of the following:

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

C. Coatings:

1. General Areas: Manufacturer's standard finish, unless bare metal surfaces are indicated.

## **2.4 THERMAL HANGER SHIELD INSERTS**

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

B. Manufacturers - subject to compliance with requirements, provide products by one of the following:

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

C. Insulation Insert Material: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

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

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

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

## **2.5 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 - subject to compliance with requirements, provide products by one of the following:

- 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 stainless 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 - subject to compliance with requirements, provide products by one of the following:
  - 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

## 2.6 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field fabricated assemblies made of manufactured corrosion-resistant components to support **floor mounted or roof mounted** piping.
- B. High Type, Single Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
  1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. ERICO/Michigan Hanger Company
    - b. MIRO Industries
    - c. Portable Pipe Hangers
  2. Base: **Plastic or Stainless steel.**
  3. Vertical Members: Two or more cadmium plated steel or stainless steel, continuous-thread rods.
  4. Horizontal Member: Cadmium plated steel or stainless steel rod with plastic or stainless steel, roller-type pipe support.
- C. High Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
  1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. Portable Pipe Hangers.
  2. Bases: One or more plastic.
  3. Vertical Members: Two or more protective-coated-steel channels.
  4. Horizontal Member: Protective-coated-steel channel.
  5. Pipe Supports: Galvanized steel, clevis-type pipe hangers.
- D. 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.

## 2.7 EQUIPMENT SUPPORTS

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

## 2.8 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, non-shrink and nonmetallic grout, suitable for interior and exterior applications.
  - 1. Properties: Non-staining, 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. 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 non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
  - 2. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
  - 3. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
  - 4. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
  - 5. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
- F. 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 (DN 20 to DN 500).
  - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.
- G. 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.



- H. Building Attachments - unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. 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.
- I. 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.
- J. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- K. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- L. 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.
  - 1. Suspend hangers from building structural members and concrete floor slabs as follows:
    - a. Install hangers plumb and free from contact with objects within ceiling plenum that are not part of supporting structural system. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
    - b. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support loads within performance limits established by referenced standards.
    - c. Secure hangers either directly to structural steel or to inserts, eye screws, or other devices that are secure and appropriate for substrate, and in a manner that will not cause them to deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
    - d. Anchors must be installed in "rib" portion of metal deck/concrete slab (thickest portion of slab).
    - e. Do not attach hangers to steel deck tabs.
    - f. Do not attach hangers to steel roof deck. Provide supplemental framing between structural members where spacing of members exceeds required spacing of hangers.

- 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.
- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Install hangers and supports to allow controlled thermal 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.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2½ (DN 65) 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.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping - comply with the following:
  - 1. Attach clamps and spacers to piping.
  - 2. Insulation shall pass through pipe hangers and pipe clamps uninterrupted.
  - 3. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

4. 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 (DN 100) and larger if pipe is installed on rollers.
5. 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 (DN 100) and larger if pipe is installed on rollers.
6. Shield Dimensions for Pipe - not less than the following:
  - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches long and 0.048 inch thick.
  - b. NPS 4 (DN 100): 12 inches long and 0.06 inch thick.
  - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches long and 0.06 inch thick.
7. Insert Material: Length at least as long as protective shield.
8. 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 1½-inches unless ceiling height dictates a smaller excess length. Coordinate with ceiling height and trim

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

**END OF SECTION 23 0529**

## **SECTION 23 0548.13 - VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Restrained spring isolators.
  - 2. Spring hangers.
  - 3. Inertia, vibration isolation equipment bases.
  - 4. In-curb acoustic treatment.

#### **1.3 DEFINITIONS**

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Wind-Restraint Loading:
  - 1. Basic Wind Speed: 90 mph.
  - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

#### **1.5 SUBMITTALS**

- A. Product Data: Include rated load, rated deflection, and overload capacity for each vibration isolation device. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of isolation device component used.
- B. In-Curb Digital Image Shop Drawing Submittal: Refer to "PART 3 - EXECUTION".
- C. Welding certificates.

#### **1.6 QUALITY ASSURANCE**

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

## **PART 2 - PRODUCTS**

### **2.1 VIBRATION ISOLATORS**

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
  2. Kinetics Noise Control
  3. Mason Industries
  4. Vibration Eliminator Co., Inc.
  5. Vibration Isolation
  6. Vibration Mountings & Controls, Inc.
- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  2. Restraint: Limit stop restraint as required for equipment to resist wind forces.
  3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- C. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
  7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

### **2.2 VIBRATION ISOLATION EQUIPMENT BASES**

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

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

## 2.3 IN-CURB ACOUSTIC TREATMENT

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
  2. BRD Noise and Vibration Control, Inc
  3. Kinetics Noise Control
  4. Mason Industries
  5. Vibration Eliminator Co., Inc.
  6. Vibration Isolation
  7. Vibration Mountings & Controls, Inc.
- B. In-curb Acoustical Treatment: The in-curb acoustical treatment shall consist of flexible sound barrier and acoustical insulation in two alternating layers of each material.
1. Flexible Sound Barrier: The flexible sound barrier shall be a 1-lb./ft.<sup>2</sup> non-reinforced barium sulfate loaded vinyl similar to Hush Block™ NRLV-100 as manufactured by BRD Noise and Vibration Control, Inc. The Flexible Sound Barrier shall exhibit a transmission loss not less than that shown below. Transmission Loss values have been tested and determined in accordance with ASTM E-90-75.

<u>Sound Transmission Loss Octave Band Center Test Frequency (in Hz) &amp; Noise Reduction (in dB)</u>						
<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>4000</u>	<u>STC</u>
13	17	22	26	32	37	26

2. Acoustical Insulation: The acoustical insulation shall be asbestos free construction, shall have low smoke and flame spread characteristics as per ASTM E-84 test, shall have a nominal 3 lbs./cubic ft. density, and shall be similar to Hush Batt™ HB-200 as manufactured by BRD Noise and Vibration Control, Inc. Acoustical Insulation shall exhibit absorption characteristics not less than that shown below. Absorption values have been tested and determined in accordance with ASTM C-423-77.

<u>Random Incident Sound Absorption Octave Band Center Test Frequency (in Hz) &amp; Absorption Values</u>						
<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>4000</u>	<u>NRC</u>
0.07	0.27	0.96	1.13	1.08	0.99	0.85

3. Extend flexible sound barrier and acoustical insulation from the outer edge of the roof curb tight to the supply and return air duct surfaces leaving no gaps for sound to penetrate through the roof deck to the space below.
4. Acoustical Sealant: All acoustical curb treatment shall be sealed completely with acoustical grade, non-hardening caulk similar to Hush Sealant™ HSAC-100 as manufactured by BRD Noise and Vibration Control, Inc.

## **2.4 FACTORY FINISHES**

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

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and equipment to receive vibration isolation and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 FIELD QUALITY CONTROL**

- A. In-Curb Digital Image Shop Drawing Submittal: Provide a shop drawing submittal, with digital images of the completed "In-Curb Acoustical Treatment", for each equipment instance/location where "In-Curb Acoustical Treatment" is specified for this project. Each digital image shall be labelled with the HVAC equipment identification tag. The Contractor shall provide the "In-Curb Digital Image Shop Drawing Submittal" a minimum of two weeks prior to concealing "In-Curb Acoustical Treatment" beneath curb mounted equipment. If this submittal is not received and approved prior to placement of applicable curb mounted HVAC equipment, the Contractor shall, at his expense, create temporary openings in the curb sides, and provide the images thru the use of a directional digital borescope.

### **3.3 VIBRATION CONTROL DEVICE INSTALLATION**

- A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- C. Install bushing assemblies for mounting bolts for wall mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.



E. Drilled-in Anchors:

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

### 3.4 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

### 3.5 VIBRATION CONTROLS SCHEDULE

A. Vibration Isolators

1. Restrained Spring Isolators - provide restrained spring isolators for the following:
  - a. Each base-mounted centrifugal pump.
2. Spring Hangers - provide spring hangers for the following:
  - a. Piping hangers installed within 20-feet upstream and downstream of in-line and base-mounted centrifugal pumps.

B. Inertia Bases

1. Provide inertia bases for the following:
  - a. Each base mounted centrifugal pump having a variable frequency drive.

C. In-Curb Acoustical Treatment

1. Provide in-curb acoustical treatment for the following:
  - a. Each roof mounted packaged heating and air conditioning unit.
  - b. Each roof mounted air handling unit.

**END OF SECTION 23 0548.13**

## **SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section includes:
  - 1. Equipment labels
  - 2. Pipe labels
  - 3. Valve tags
  - 4. Ceiling valve markers

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Valve Schedules: For each piping system to include in maintenance manuals.

#### **1.4 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: Provide metal labels containing equipment performance data if not furnished and attached to the equipment item at the factory.
  - 1. Material and Thickness: Aluminum, 0.032-inch or anodized aluminum, 0.032-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 3/4 inch.
  - 3. Minimum Letter Size: 1/4 inch.

4. Fasteners: Stainless steel rivets or self-tapping screws.
  5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
  6. Label Content: Include equipment's performance data including capacity and electrical data.
- B. Plastic Labels for Equipment: Provide plastic label for each HVAC equipment item.
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°F.
  5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
  6. Minimum Letter Size: 1/2 inch for viewing distances up to 72 inches.
  7. Fasteners: Stainless steel rivets or self-tapping screws.
  8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
  9. Label Content: Include equipment's drawing designation or unique equipment number.

## **2.2 PIPE LABELS**

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and/or pipe insulation, and to attach to pipe without fasteners or adhesive.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Flow Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
  2. Lettering Size: At least 1-1/2 inches high.

## **2.3 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, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
  2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

## **2.4 CEILING VALVE MARKERS**

- A. Ceiling Valve Markers: Round adhesive solid color stickers, 3/4-inch diameter.
  - 1. Color of markers shall be the same for similar applications.
  - 2. Colors of markers shall be one of the following: yellow, orange, red, magenta, lavender, blue, green, dark green, dark blue, purple, brown, black plus fluorescent green, yellow, orange and pink.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

- A. Clean piping and equipment surface 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 25 feet along each run.
  - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Pipe Label Color Schedule
  - 1. Condenser Water Piping:
    - a. Background Color: Green.
    - b. Letter Color: White.
  - 2. Coil Condensate Drain Piping:
    - a. Background Color: Green.
    - b. Letter Color: White.

- 3. Non-Potable Water Piping:
  - a. Background Color: Yellow.
  - b. Letter Color: Black.

### **3.4 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; 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: 2 inches round.
  - 2. Valve Tag Color: Natural.
  - 3. Letter Color: Black

### **3.5 CEILING VALVE MARKER INSTALLATION**

- A. Install ceiling valve markers on metal ceiling grid nearest to valves and control devices located above lay-in ceilings.

### **3.6 NON-POTABLE WATER OUTLETS**

- A. Provide a plastic equipment label at each non-potable water outlet, such as hose bibbs. The label shall read "NON-POTABLE WATER --- DO NOT DRINK --- AVOID CONTACT."

**END OF SECTION 23 0553**

## **SECTION 23 0593 - 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes
  - 1. Balancing Air Systems:
    - a. Constant volume air systems.
    - b. Variable air volume systems.
  - 2. Balancing Hydronic Piping Systems:
    - a. Constant flow hydronic systems.
    - b. Variable flow hydronic systems.

#### **1.3 DEFINITIONS**

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

#### **1.4 SUBMITTALS**

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

## **1.5 QUALITY ASSURANCE**

- A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB, AABC, or TABB.
  - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by NEBB, AABC, or TABB.
  - 2. TAB Technician: Employee of the TAB contractor and who is certified by NEBB, AABC, or TABB as a TAB technician.
- B. TAB Conference: Meet with Architect, Owner, Construction Manager, and Commissioning Agent on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide fourteen (14) days advance notice of scheduled meeting time and location.
  - 1. Agenda Items:
    - a. The Contract Documents examination report.
    - b. The TAB plan.
    - c. Coordination and cooperation of trades and subcontractors.
    - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:
  - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
  - 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard TAB contractor's forms published by AABC or NEBB.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

## **1.6 PROJECT CONDITIONS**

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

## **1.7 COORDINATION**

- A. Notice: Provide seven (7) days advance notice to the Contractor and Owner prior to commencement of TAB work. Include scheduled test dates and times. Provide seven (7) days advance notice to any changes in the scheduled dates and times.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
- C. Coordinate with ATC Contractor to balance RTU and OAU damper positions. Pay particular attention to minimum outside air damper position as listed in Division 23 Section 23 0993 "Sequence of Operations for HVAC Control."



## **1.8 TAB SPECIALISTS**

- A. Subject to compliance with requirements, engage one of the following independent TAB contractors to provide the TAB work:
  - 1. Kahoe Air Balance Company
  - 2. Northstar Environmental, Ltd.
  - 3. WAE Balancing, Inc.

## **PART 2 - PRODUCTS (Not Applicable)**

## **PART 3 - EXECUTION**

### **3.1 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. Notify contractor, Architect and Engineer immediately upon discovery of any deficiencies.
- B. Examine systems for installed balancing devices, such as test ports, gauge cocks, thermometer wells, flow control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible. Notify contractor immediately upon discovery of any balancing devices not present that will prevent balancing of the system.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine ceiling 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 23 3113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- E. Verify that transfer ducts or penetrations in plenum walls exist to enable air flow through plenum as indicated or required.
- F. Examine equipment performance data including fan and pump curves.
- G. Obtain and examine start-up test reports to verify that start-up testing, cleaning, and adjusting of HVAC equipment and systems have been performed prior to the commencement of TAB work.
- H. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- I. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- K. Examine system pumps to ensure absence of entrained air in the suction piping.
- L. Examine operating safety interlocks and controls on HVAC equipment.
- M. Report deficiencies discovered before and during performance of TAB procedures to the contractor, Architect and Engineer.

### **3.2 PREPARATION**

- A. Complete system-readiness checks. 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. Balancing 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.

### **3.3 GENERAL PROCEDURES FOR TESTING, ADJUSTING AND BALANCING**

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance," NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing," and the requirements contained in this Section.
- 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. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section 23 0713 "Duct Insulation", Section 23 0716 "HVAC Equipment Insulation" and Section 23 0719 "HVAC Piping Insulation".
- C. Mark equipment and balancing devices, including damper control positions, valve position indicators, fan speed control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch pound (IP) units.

### **3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS**

- A. Where the Drawings require the HVAC trade to demolish and/or modify only a portion of an existing air system and the remainder of the system is to remain in service, the Testing, Adjusting and Balancing (TAB) trade shall measure the air flow rates in the undisturbed portions of system prior to disconnecting work in the construction areas. The TAB trade shall rebalance the affected systems to these measurements immediately following the disconnection of the ductwork being demolished/modified and also immediately after placing the new/modified system into service.
- B. 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.
- C. For variable air volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

- E. Check airflow patterns from the outdoor air louvers and dampers and the return and exhaust air dampers through the supply fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air handling unit components.
- L. Verify that air duct system is sealed as specified in Division 23 Section 23 3113 "Metal Ducts."

### **3.5 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 at outlet of supply fans or inlet of exhaust fans using Pitot-tube traverse measurements.
    - 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 as follows to determine actual static pressure:
    - a. Measure outlet static pressure as far downstream from the fan as practical 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 the 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 outside air unit, rooftop unit, and other air handling and treating equipment.
    - a. Report the cleanliness status of filters at the time static pressures are measured.
  - 4. For each fan on the project, make adjustment of fan speed higher or lower than scheduled speed in order to achieve design airflow rates. Comply with requirements in Division 23 sections for air handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air handling unit performance.
    - a. For each belt driven fan, provide one complete belt and sheave change in order to balance the fan to the design airflow rate.
    - b. 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 mode 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 airflow of submain and branch ducts at terminal outlets and inlets without making adjustments and calculate the total airflow for that zone.
    - a. Measure terminal outlets using a direct reading hood or outlet manufacturer's written instructions and calculating factors.
  - 2. Adjust volume dampers until the proper airflow rate for that zone is achieved.
  - 3. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch 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.

### **3.6 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 minimum set-point airflow with the remainder at maximum-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.

### **3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS**

- A. Where the Drawings require the HVAC trade to demolish and/or modify only a portion of an existing water system and the remainder of the system is to remain in service, the Testing, Adjusting and Balancing (TAB) trade shall measure the water flow rates in the undisturbed portions of system prior to disconnecting work in the construction areas. The TAB trade shall rebalance the affected systems to these measurements immediately following the disconnection of the piping being demolished/modified and also immediately after placing the new/modified system into service.
- B. 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 the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- 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 liquid level in expansion tank.
  - 3. Check makeup water station pressure gauge 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.
  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.
- D. Systems installed with pressure independent control valves shall not require terminal level hydronic system balancing. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for locations where calibrated orifice, balancing valves are required to be installed.
1. Field verify installation and operating differential pressure range of all pressure independent control valves. Any individual adjustments for the pressure independent control valve assembly (valve and actuator combination) for field conditions shall be performed using the pressure independent control valve manufacturer's documented procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).

### **3.8 PROCEDURES FOR CONSTANT FLOW 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 gauge heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
  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. If the adjustment to the pump discharge valve results in a pressure drop of 20 feet or greater across the valve, provide an impeller trim. Comply with requirements in Division 23 Section 23 2123 "Hydronic Pumps." If an impeller is trimmed, note the beginning diameter and final diameter in the balance report.
    - b. If the flow rate is greater than 10% below the scheduled design flow rate with all valves open, notify the Architect and Engineer immediately to discuss an impeller change.
    - c. 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 10 percent of design.
- B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- C. Set calibrated balancing valves, at calculated pre-settings.
- D. 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.

- E. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- F. Wherever constant volume pumps are equipped with a variable frequency controller and a triple duty valve; use the triple duty valve to measure the flow rate and use the variable frequency controller to achieve flow that is 5 percent greater than indicated flow.
  - 1. The triple duty valve shall be placed in its full-open position and shall only be used for flow measurement purposes, for shutoff purposes, and flow short-circuit prevention purposes (check function).
  - 2. The variable frequency controller shall be used for flow balancing. Once correct flow is achieved, the corresponding frequency shall be documented in the Operations and Maintenance manual. The corresponding frequency shall also be 'labeled' on the variable frequency controller.
- 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 conclusion of balancing.
- J. Check settings and operation of each safety valve. Record settings.

### **3.9 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.

### **3.10 PROCEDURES FOR MOTORS**

- A. Motors, 1/2 HP and Larger - test at final balanced conditions and record the following data:
  - 1. Manufacturer's name, model number, and serial number.
  - 2. Motor horsepower rating.
  - 3. Motor rpm.
  - 4. 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 of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

### **3.11 PROCEDURES FOR HEAT TRANSFER COILS**

- A. Measure, adjust, and record the following data for each water coil:
  - 1. Water flow rate.
  - 2. Water pressure drop.
  - 3. Airflow.
  - 4. Air pressure drop.
- B. Measure, adjust, and record the following data for each electric heating coil:
  - 1. Nameplate data.
  - 2. Airflow.
  - 3. Voltage and amperage input of each phase at full load and at each incremental stage.
  - 4. Fuse or circuit breaker rating for overload protection.
- C. Measure, adjust, and record the following data for each refrigerant coil:
  - 1. Airflow.
  - 2. Air pressure drop.

### **3.12 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS**

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
  - 1. Measure and record the operating speed, airflow, and static pressure of each fan.
  - 2. Measure and record the water flow and head of each pump.
  - 3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
  - 4. Check the condition of filters.
  - 5. Check the condition of coils.
  - 6. Check the condition and operation of the drain pan and condensate-drain trap.
  - 7. Check bearings and other lubricated parts for condition and proper operation.
  - 8. Measure the airflow rate at each air terminal inlet and outlet.
  - 9. Measure the water flow rate at each equipment item in the system.
  - 10. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
  - 1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
  - 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
  - 3. If design flow rates increase or decrease the measured airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
  - 4. Balance each air outlet.

### 3.13 TOLERANCES

- A. Set HVAC system's **air flow rates and water flow rates** within the following tolerances:
1. Supply, Return, Relief and Exhaust Fans and Equipment with Fans: Zero to plus 5 percent of scheduled design flow.
  2. Air Outlets and Inlets: Plus, or minus 10 percent of design flow indicated.
  3. Heat Pump Condenser Water Pump Flow Rate: Zero to plus 5 percent of scheduled design flow.

### 3.14 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
  2. Include a list of instruments used for procedures, along with proof of calibration.
  3. Not all components listed below apply to this project. Provide data for each existing component, or component furnished to the jobsite as applicable.
- B. Final Report Contents - in addition to certified field report data, include the following:
1. Field test reports (start-up reports) prepared by system and equipment installers.
  2. Other information relative to equipment performance such as fan curves and pump curves; do not include Shop Drawings and product data.
- C. General Report Data - in addition to form titles and entries, include the following data:
1. Title page.
  2. Name and address of the TAB contractor.
  3. Project name.
  4. Project location.
  5. Architect's name and address.
  6. Engineer's name and address.
  7. Contractor's name and address.
  8. Report date.
  9. Signature of TAB supervisor who certifies the report.
  10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  11. Summary of contents including the following:
    - a. Indicated versus final performance.
    - b. Notable characteristics of systems.
  12. Nomenclature sheets for each item of equipment.
  13. Data for terminal units, including manufacturer's name, type, size, and fittings.
  14. Notes to explain why certain final data in the body of reports vary from indicated values.
  15. Test conditions for fan and pump performance forms including the following:
    - a. Settings for outdoor, return, and exhaust air dampers.
    - b. Conditions of filters.
    - c. Cooling coil, wet- and dry-bulb conditions.
    - d. Variable frequency drive settings for variable air volume systems.
    - e. Settings for supply air, static pressure controller.
    - f. Other system operating conditions that affect performance.



- D. **Outside Air Unit and Rooftop Unit** Test Reports - for **outside air units and rooftop units** with coils, include the following:
1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Unit arrangement and class.
    - g. Discharge arrangement.
  2. Fan data - for each fan, include the following:
    - a. Fan sheave make, size in inches and bore.
    - b. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    - c. Number, make, and size of belts.
    - d. Number, type, and size of filters.
  3. Motor data - for each motor, include the following:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.
    - e. Motor sheave make, size in inches and bore.
    - f. Center-to-center dimensions of fan and motor sheaves, and amount of adjustments in inches.
  4. Coil data - for each coil, include the following:
    - a. System identification.
    - b. Location.
    - c. Coil type.
    - d. Number of rows.
    - e. Fin spacing in fins per inch o.c.
    - f. Rated voltage and amperage of each phase.
    - g. Capacity in KW.
    - h. Make and model number.
    - i. Face area in sq. ft.
    - j. Tube size in NPS (DN).
    - k. Circuiting arrangement.
  5. Gas fired Heat Exchanger Data - for each gas-fired heat exchanger in rooftop units, include the following:
    - a. Location.
    - b. Make and type.
    - c. Fuel type.
    - d. Output capacity in Btu/h.
    - e. Ignition type.
    - f. Burner control types.
    - g. Burner motor volts, phase, hertz, rpm and horsepower.

6. Unit Test Data (Indicated and Actual Values):

- a. Total air flow rate in cfm.
- b. Outdoor airflow in cfm.
- c. Return airflow in cfm.
- d. Total system static pressure in inches wg.
- e. Fan rpm for each fan.
- f. Voltage at each connection.
- g. Amperage for each phase.
- h. Unit discharge static pressure in inches wg.
- i. Unit inlet static pressure in inches wg.
- j. Filter static pressure differential in inches wg for each filter bank.
- k. Outdoor air damper position.
- l. Return air damper position.
- m. Relief-air damper position.
- n. Air blender static pressure differential in inches wg.
- o. Variable frequency drive speed (for each fan).

7. Coil Test Data (Indicated and Actual Values) - for each coil, include the following:

- a. Average face velocity in fpm.
- b. Air pressure drop in inches wg.
- c. Water flow rate in gpm.
- d. Water pressure differential in feet of head or psig.
- e. Inlet steam pressure in psig.
- f. Voltage at each connection.
- g. Amperage for each phase.

8. Gas fired Heat Exchanger Test Data (Indicated and Actual Values):

- a. Air static pressure differential in inches wg.

E. Round and Rectangular Duct Traverse Reports: For main supply and return ducts for each system, include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

- a. System and air handling unit number.
- b. Location and zone.
- c. Traverse air temperature in degree F.
- d. Duct static pressure in inches wg.
- e. Duct size in inches.
- f. Duct area in sq. ft.
- g. Indicated air flow rate in cfm.
- h. Indicated velocity in fpm.
- i. Actual air flow rate in cfm.
- j. Actual average velocity in fpm.
- k. Barometric pressure in psig.

F. Air Terminal Device Reports - for each diffuser, register and grille, include the following:

1. Unit Data:
  - a. System and air handling unit identification.
  - b. Location and zone.
  - c. Apparatus used for test.
  - d. Area served.
  - e. Make.
  - f. Number from system diagram.
  - g. Type and model number.
  - h. Size.
  - i. Effective area in square feet.
  - j. Design air flow rate in cfm.
2. Test Data (Indicated and Actual Values):
  - a. Air flow rate in cfm.
  - b. Air velocity in fpm.
  - c. Preliminary air flow rate in cfm.
  - d. Preliminary velocity in fpm.
  - e. Final air flow rate in cfm.
  - f. Final velocity in fpm.

G. Pump Test Reports - calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:
  - a. Unit identification.
  - b. Location.
  - c. Service.
  - d. Make and size.
  - e. Model number and serial number.
  - f. Water flow rate in gpm.
  - g. Water pressure differential in feet of head or psig.
  - h. Required net positive suction head in feet of head or psig.
  - i. Pump rpm.
  - j. Impeller diameter in inches.
  - k. Motor make and frame size.
  - l. Motor horsepower and rpm.
  - m. Voltage at each connection.
  - n. Amperage for each phase.
  - o. Seal type.
2. Test Data (Indicated and Actual Values):
  - a. Static head in feet of head or psig.
  - b. Pump shutoff pressure in feet of head or psig.
  - c. Actual impeller size in inches.
  - d. Full-open flow rate in gpm.
  - e. Full-open pressure in feet of head or psig.

- f. Final discharge pressure in feet of head or psig.
- g. Final suction pressure in feet of head or psig.
- h. Final total pressure in feet of head or psig.
- i. Final water flow rate in gpm.
- j. Voltage at each connection.
- k. Amperage for each phase.

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.

### 3.15 INSPECTIONS

A. Owner Inspection

- 1. After testing and balancing work is complete and accurately documented in the final report, the TAB subcontractor shall request that a final inspection be made by the Owner or his representative.
- 2. The TAB subcontractor shall conduct the inspection in the presence of the Owner or his representative.
- 3. The Owner or his representative will randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 15 percent of the total measurements recorded.
- 4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- 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.

B. TAB Work will be considered defective if it does not pass the Owner inspection. If the 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 Owner inspection.
- 2. If the second Owner inspection also fails, Owner may request the HVAC Trade to contract the services of another TAB subcontractor to complete TAB Work according to the Contract Documents or the Owner may contract the services of another TAB subcontractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the HVAC contractor's final payment.

C. Prepare test and inspection reports.

### **3.16      ADDITIONAL TESTS**

- A.      Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B.      Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

**END OF SECTION 23 0593**

## **SECTION 23 0713 - DUCT 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes
  - 1. Insulation Materials:
    - a. Mineral fiber.
  - 2. Factory assembled, double layer, pre-insulated phenolic ductwork.
  - 3. Fire rated insulation systems.
  - 4. Adhesives.
  - 5. Mastics.
  - 6. Lagging adhesives.
  - 7. Sealants.
  - 8. Factory applied jackets.
  - 9. Field applied fabric reinforcing mesh.
  - 10. Field applied cloths.
  - 11. Field applied jackets.
  - 12. Tapes.
  - 13. Securements.
  - 14. Corner angles.

#### **1.3 SUBMITTALS**

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

#### **1.4 QUALITY ASSURANCE**

- A. Fire test response Characteristics: Insulation and related materials shall have fire test response characteristics indicated below as tested in accordance with ASTM E 84.
  - 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.

B. Underwriters Laboratories (UL):

1. UL 181 - Standards for Factory Made Air Ducts and Air Connectors.
2. UL 723 - Standard Test Method for Surface Burning Characteristics of Building Materials.

## 1.5 COORDINATION

- A. Coordinate clearance requirements with duct installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field applied jackets and finishes and for space required for maintenance.

## PART 2 - PRODUCTS

### 2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Mineral fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory applied FSK jacket. Factory applied jacket requirements are specified in "Factory applied Jackets" article.
1. Products - subject to compliance with requirements, provide the following:
    - a. CertainTeed Corp.; Duct Wrap.
    - b. Johns Manville; Microlite.
    - c. Knauf Insulation; Duct Wrap.
    - d. Manson Insulation Inc.; Alley Wrap.
    - e. Owens Corning; All-Service Duct Wrap.
- F. Mineral fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory applied FSK jacket. Factory applied jacket requirements are specified in "Factory applied Jackets" article.
1. Products - subject to compliance with requirements, provide the following:
    - a. CertainTeed Corp.; Commercial Board
    - b. Fibrex Insulations Inc.; FBX
    - c. Knauf Insulation; Insulation Board
    - d. Johns Manville; 800 Series Spin-Glas.
    - e. Manson Insulation Inc.; AK Board
    - f. Owens Corning; Fiberglas 700 Series

## **2.2 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. Mineral fiber adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-82.
    - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
    - d. Marathon Industries, Inc.; 225.
    - e. Mon-Eco Industries, Inc.; 22-25.
- C. FSK Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-82.
    - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
    - d. Marathon Industries, Inc.; 225.
    - e. Mon-Eco Industries, Inc.; 22-25.

## **2.3 MASTICS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-35.
    - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    - c. ITW TACC, Division of Illinois Tool Works; CB-50.
    - d. Marathon Industries, Inc.; 590.
    - e. Mon-Eco Industries, Inc.; 55-40.
    - f. Vimasco Corporation; 749.
  - 2. Water Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 3. Service Temperature Range: Minus 20° to plus 180°F.
  - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
  - 5. Color: White.



## **2.4 SEALANTS**

### **A. FSK and Metal Jacket Flashing Sealants**

1. Products - subject to compliance with requirements, provide the following:
  - a. Childers Products, Division of ITW; CP-76-8.
  - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
  - c. Marathon Industries, Inc.; 405.
  - d. Mon-Eco Industries, Inc.; 44-05.
  - e. Vimasco Corporation; 750.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire and water resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40° to plus 250°F.
5. Color: Aluminum.

## **2.5 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. FSK Jacket: Aluminum foil, fiberglass reinforced scrim with Kraft paper backing; complying with ASTM C 1136, Type II.

## **2.6 FIELD APPLIED JACKETS**

### **A. Field applied jackets shall comply with ASTM C 921, Type I, for ducts operating at below ambient temperatures and Type II, for ducts operating at above ambient temperatures.**

### **B. Metal Jacket**

1. Products - subject to compliance with requirements, provide the following:
  - a. Childers Products, Division of ITW; Metal Jacketing Systems.
  - b. PABCO Metals Corporation; Surefit.
  - c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
  - a. Factory cut and rolled to size; or, sheet and roll stock ready for shop or field sizing.
  - b. Finish and thickness are indicated in field applied jacket schedules.
  - c. Moisture Barrier for Outdoor Applications: 2.5-mil thick Polysurlyn.

## 2.7 TAPES

- A. FSK Tape: Foil face, vapor retarder tape matching factory applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products - subject to compliance with requirements, provide the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    - b. Compac Corp.; 110 and 111.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
    - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
  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.
- B. Aluminum Foil Tape: Vapor retarder tape with acrylic adhesive.
1. Products - subject to compliance with requirements, provide the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    - b. Compac Corp.; 120.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
    - d. Venture Tape; 3520 CW.
  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.

## 2.8 SECUREMENTS

- A. Bands
1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products; Bands.
    - b. PABCO Metals Corporation; Bands.
    - c. RPR Products, Inc.; Bands.
  2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
- B. Insulation Pins and Hangers
1. Capacitor Discharge Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor discharge welding, minimum 0.106-inch diameter shank, length, to suit depth of insulation indicated.

- a. Products - subject to compliance with requirements, provide the following:
  - 1) AGM Industries, Inc.; CWP-1.
  - 2) GEMCO; CD.
  - 3) Midwest Fasteners, Inc.; CD.
  - 4) Nelson Stud Welding; TPA, TPC, and TPS.
- 2. Cupped-Head, Capacitor Discharge Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor discharge welding, minimum 0.106-inch diameter shank diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon steel washer.
  - a. Products - subject to compliance with requirements, provide the following:
    - 1) AGM Industries, Inc.; CWP-1.
    - 2) GEMCO; Cupped Head Weld Pin.
    - 3) Midwest Fasteners, Inc.; Cupped Head.
    - 4) Nelson Stud Welding; CHP.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.
  - 1. Manufacturers - subject to compliance with requirements, provide the following:
    - a. C & F Wire
    - b. Childers Products
    - c. PABCO Metals Corporation
    - d. RPR Products, Inc.

## 2.9 CORNER ANGLES

- A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
  - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
  - 2. Verify that surfaces to be insulated are clean and dry.
  - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

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

- B. 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 ducts and fittings.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each duct system as specified in the 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. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, and other projections with vapor barrier mastic.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. 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 duct. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below ambient services, apply vapor barrier mastic over staples.
  - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above ambient services, do not install insulation to the following:
  - 1. Vibration control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.

### **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 Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
  - 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire rated walls and partitions. Terminate insulation at fire damper sleeves for fire rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
  - 1. Comply with requirements in Division 07 for fire-stopping and fire-resistive joint sealers.

### **3.5 MINERAL FIBER INSULATION INSTALLATION**

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
  - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install either capacitor discharge weld pins and speed washers or cupped-head, capacitor discharge weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

- b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    - d. Do not over compress insulation during installation.
    - e. Impale insulation over pins and attach speed washers.
    - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory or field applied jacket, adhesive, vapor barrier mastic, and sealant at joints, seams, and protrusions.
    - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor barrier seal.
    - b. Install vapor stops for ductwork and plenums operating below 50°F at 18-foot intervals. Vapor stops shall consist of vapor barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
  - 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
  - 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
  - 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install either capacitor discharge weld pins and speed washers or cupped-head, capacitor discharge weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    - d. Do not over compress insulation during installation.
    - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c.

5. Install vapor barrier consisting of factory or field applied jacket, adhesive, vapor barrier mastic, and sealant at joints, seams, and protrusions.
  - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor barrier seal.
  - b. Install vapor stops for ductwork and plenums operating below 50°F at 18-foot intervals. Vapor stops shall consist of vapor barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

### **3.6 FIELD APPLIED JACKET INSTALLATION**

- A. 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.
- B. 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.

### **3.7 INSULATION SCHEDULE FOR DUCTS AND PLENUMS INSTALLED INDOORS**

- A. Existing Ducts
  1. Existing, concealed; rectangular, round and flat-oval, including square to round transitions; supply air duct insulation shall be the following:
    - a. Mineral fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
  2. Existing, concealed or exposed; rectangular, round and flat-oval; outdoor air duct insulation shall be the following:
    - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.

B. Supply Air Ducts

1. Concealed; round and flat-oval; duct insulation shall be the following:
  - a. Mineral fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
2. Concealed; rectangular; duct insulation shall be the following:
  - a. Mineral fiber Blanket: 1½-inches thick and 1.50-lb/cu. ft. nominal density.
  - b. Ductwork shall be internally insulated. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.

C. Unconditioned Outdoor Air Ducts

1. Concealed or exposed; rectangular; duct and plenum insulation shall be the following:
  - a. Mineral fiber Board: 2 inches thick and 3.0-lb/cu. ft. nominal density.

D. Return Air Ducts

1. Concealed or exposed, rectangular, duct insulation shall be the following:
  - a. Ductwork shall be internally insulated for a distance of 50 feet upstream of the air handling unit or rooftop air handling unit. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.

E. Exhaust Air Ducts - General Purpose

1. Concealed; rectangular; duct and plenum insulation, installed between the exhaust air louver or exhaust air gravity roof hood and a point 24-inches upstream of the automatic air damper, shall be the following:
  - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.

F. Relief Air Ducts

1. Concealed; rectangular; duct and plenum insulation, installed between the relief air louver or relief air gravity roof hood and a point 24-inches upstream of the automatic-air damper, shall be the following:
  - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.

G. Heat Recovery Unit Supply Air Ducts

1. For systems where the supply air temperature is 60°F and lower:
  - a. Concealed; round and flat-oval; duct insulation shall be the following:
    - 1) Mineral fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
  - b. Concealed; rectangular; duct insulation shall be the following:
    - 1) Mineral fiber Blanket: 1½-inches thick and 1.50-lb/cu. ft. nominal density.



H. Heat Recovery Unit Exhaust Air Ducts (Upstream of Unit):

1. Concealed or exposed, rectangular, duct insulation shall be the following:
  - a. Ductwork shall be internally insulated for a distance of 50 feet upstream of the air handling unit or rooftop air handling unit. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.

**3.8 INSULATION SCHEDULE FOR DUCTS AND PLENUMS INSTALLED OUTDOORS**

- A. Rectangular; supply air, return air, outdoor air, relief air and exhaust air duct insulation shall be the following:
1. Mineral fiber Board: 2 inches thick and 6.0-lb/cu. ft. minimum nominal density.
    - a. For exposed ducts, provide a field applied jacket. Jacket shall be capable of being field painted. Refer to "Field applied Jacket Schedule for Ducts Installed Indoors" article in this section for requirements.

**3.9 FIELD APPLIED JACKET SCHEDULE FOR DUCTS INSTALLED OUTDOORS**

- A. Install jacket over insulation material. For insulation with factory applied jacket, install the field applied jacket over the factory applied jacket.
- B. Ducts and Plenums:
1. Aluminum, Smooth: 0.024 inch thick.
- C. Provide waterproof sealant over jacketing.

**END OF SECTION 23 0713**

## **SECTION 23 0716 - HVAC EQUIPMENT 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes
  - 1. Insulation Materials:
    - a. Flexible elastomeric.
    - b. Mineral fiber.
  - 2. Adhesives.
  - 3. Mastics.
  - 4. Sealants.
  - 5. Factory applied jackets.
  - 6. Field applied jackets.
  - 7. Tapes.
  - 8. Securements.

#### **1.3 SUBMITTALS**

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

#### **1.4 QUALITY ASSURANCE**

- A. Fire Test Response Characteristics: Insulation and related materials shall have fire test response characteristics indicated below as tested in accordance with ASTM E 84.
  - 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.

#### **1.5 COORDINATION**

- A. Coordinate size and location of supports and hangers specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

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

## **PART 2 - PRODUCTS**

### **2.1 INSULATION MATERIALS**

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Aeroflex USA Inc.; Aerocel.
    - b. Armacell LLC; AP Armaflex.
    - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

### **2.2 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. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Aeroflex USA Inc.; Aeroseal.
    - b. Armacell LCC; 520 Adhesive.
    - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
    - d. RBX Corporation; Rubatex Contact Adhesive.

### **2.3 MASTICS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-35.
    - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    - c. ITW TACC, Division of Illinois Tool Works; CB-50.
    - d. Marathon Industries, Inc.; 590.
    - e. Mon-Eco Industries, Inc.; 55-40.
    - f. Vimasco Corporation; 749.

2. Water Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20° to plus 180°F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

## **2.4 FIELD APPLIED JACKETS**

### **A. Metal Jacket**

1. Products - subject to compliance with requirements, provide the following:
  - a. Childers Products, Division of ITW; Metal Jacketing Systems.
  - b. PABCO Metals Corporation; Surefit.
  - c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
  - a. Factory cut and rolled to size; or, sheet and roll stock ready for shop or field sizing.
  - b. Finish and thickness are indicated in field applied jacket schedules.
  - c. Moisture Barrier for Outdoor Applications: 2.5-mil thick Polysurlyn.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
  1. Verify that systems and equipment to be insulated have been tested and are free of defects.
  2. Verify that surfaces to be insulated are clean and dry.
  3. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. 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 equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment 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 multiple layers of insulation with longitudinal and end seams staggered.
- E. Keep insulation materials dry during application and finishing.
- F. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- G. Install insulation with least number of joints practical.
- H. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at supports and other projections with vapor barrier mastic.
- I. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- J. 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. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below ambient services, apply vapor barrier mastic over staples.
  - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- K. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- L. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- M. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- N. For above ambient services, do not install insulation to the following:
  - 1. Vibration control devices
  - 2. Testing agency labels and stamps
  - 3. Nameplates and data plates
  - 4. Manholes
  - 5. Handholes

### 3.4 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

- A. Mineral Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
  2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
  3. Protect exposed corners with secured corner angles.
  4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
    - a. Do not weld anchor pins to ASME-labeled pressure vessels.
    - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    - d. Do not over compress insulation during installation.
    - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    - f. Impale insulation over anchor pins and attach speed washers.
    - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
  6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
  7. Stagger joints between insulation layers at least 3 inches.
  8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
  9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
  10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
  2. Fabricate boxes from aluminum, at least 0.040 inch thick.
  3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

### **3.5 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION**

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

### **3.6 FIELD APPLIED JACKET INSTALLATION**

- A. 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.

### **3.7 FINISHES**

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless steel jackets.

### **3.8 EQUIPMENT INSULATION SCHEDULE**

- A. Pump insulation shall be the following:
  - 1. Flexible Elastomeric: 2 inch thick.

**END OF SECTION 23 0716**

## **SECTION 23 0719 - 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

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

#### **1.3 SUBMITTALS**

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

#### **1.4 QUALITY ASSURANCE**

- A. Fire Test Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated below as tested in accordance with ASTM E 84.
  - 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.



## **1.5 COORDINATION**

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section 23 0529 "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.

## **1.6 SCHEDULING**

- A. Schedule insulation application after pressure testing systems. 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 Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- E. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Aeroflex USA Inc.; Aerocel.
    - b. Armacell LLC; AP Armaflex.
    - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

### **2.2 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. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Aeroflex USA Inc.; Aero seal.
    - b. Armacell LCC; 520 Adhesive.
    - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
    - d. RBX Corporation; Rubatex Contact Adhesive.

## **2.3 MASTICS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-35.
    - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    - c. ITW TACC, Division of Illinois Tool Works; CB-50.
    - d. Marathon Industries, Inc.; 590.
    - e. Mon-Eco Industries, Inc.; 55-40.
    - f. Vimasco Corporation; 749.
  - 2. Water Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 3. Service Temperature Range: Minus 20° to plus 180°F.
  - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
  - 5. Color: White.

## **2.4 SEALANTS**

- A. ASJ Flashing Sealants and PVC Jacket Flashing Sealants
  - 1. Products - subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-76.
  - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 3. Fire- and water-resistant, flexible, elastomeric sealant.
  - 4. Service Temperature Range: Minus 40° to plus 250°F.
  - 5. Color: White.

## **2.5 FACTORY APPLIED JACKETS**

- A. Insulation system schedules indicate factory applied jackets on various applications. When factory applied jackets are indicated, comply with the following:
  - 1. ASJ: White, Kraft paper, fiberglass reinforced scrim with aluminum foil backing; complying with ASTM C 1136, Type I.
  - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

## **2.6 FIELD APPLIED JACKETS**

- A. Field applied jackets shall comply with ASTM C 921, Type I, for pipes operating at below ambient temperatures.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 30 mils thickness; roll stock ready for shop or field cutting and forming. Thickness is indicated in field applied jacket schedules.

1. Products - subject to compliance with requirements, provide the following:
  - a. Johns Manville; Zeston.
  - b. P.I.C. Plastics, Inc.; FG Series.
  - c. Proto PVC Corporation; LoSmoke.
  - d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
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.
5. Factory fabricated tank heads and tank side panels.

## **2.7 TAPES**

- A. PVC Tape: White vapor-retarder tape matching field applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
1. Products - subject to compliance with requirements, provide the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    - b. Compac Corp.; 130.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
    - d. Venture Tape; 1506 CW NS.
  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.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
  2. Verify that surfaces to be insulated are clean and dry.
  3. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. 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 thicknesses required for each 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. Insulation installed on piping systems shall pass through pipe hangers and pipe clamps uninterrupted.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during application and finishing.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
  - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Install insulation with factory applied jackets as follows:
  - 1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below ambient services, apply vapor-barrier mastic over staples.
  4. Cover joints and seams with tape as recommended by insulation material manufacturer 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.
- N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- Q. For above ambient services, do not install insulation to the following:
1. Vibration control devices
  2. Cleanouts

### **3.4 PENETRATIONS**

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- B. Insulation Installation at Fire Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire rated walls and partitions.
1. Comply with requirements in Division 07 for fire-stopping and fire-resistive joint sealers.

### **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, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
  2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
  3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
  5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
  6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
  7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
  8. For services not specified to receive a field applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
  9. Label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

### **3.6 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION**

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
  2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
  4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
  2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

### 3.7 FIELD APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

### 3.8 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

### 3.9 INSULATION SCHEDULE FOR PIPING INSTALLED INDOORS

- A. Condensate and Equipment Drain Water below 60°F:
1. All Pipe Sizes: Flexible Elastomeric, 3/4 inch thick.
- B. Geothermal Water, 30° to 100°F:
1. All Pipe Sizes: Flexible Elastomeric, 2 inches thick.

**END OF SECTION 23 0719**

## SECTION 23 0801 - COMMISSIONING OF HVAC

### PART 1 - GENERAL

#### 1.1 DESCRIPTION

- A. The **HVAC** Contractor will procure the services of independent Commissioning Consultant; other terms are Commissioning Provider, Commissioning Agent, and Commissioning Authority. The Commissioning Consultant shall be an independent and knowledgeable third party, contracted to verify that the HVAC systems, service water heating systems, lighting control systems, and other systems where indicated below, operate as illustrated, described or specified in the contract documents. The Commissioning Consultant will inform the **Engineer** of the results of the commissioning and provide suggestions, as necessary, to correct deficiencies in observed performance or installation.
- B. Commissioning is the process to verify to The HVAC Contractor that systems, equipment, mechanical, electrical, controls and special systems function together properly to meet performance requirements and design intent, and as described in the Contract Documents. The **HVAC** Contractor shall be responsible for participation in the commissioning process as outlined below and in references and attachments throughout the Contract Documents. The **HVAC** Contractor shall furnish labor and materials sufficient to meet all requirements of building commissioning under this contract.
- C. Various sections in the Division 00, 01, 22, 23 and 26 Specifications as well as specifications in other sections outline the specific commissioning responsibilities of each Contractor and corresponding subcontractors for the respective division and obligate the **HVAC** Contractor to coordinate and manage the commissioning responsibility of those subcontractors.

#### 1.2 REQUIREMENTS INCLUDED

- A. Duties of Contractor.
- B. Duties of Commissioning Consultant.
- C. Commissioning Field Notebook.
- D. Acceptance Procedures.
- E. Performance Period.
- F. Training and Instruction.

#### 1.3 RELATED SECTIONS

- A. All Division 1 Sections and General Requirements
- B. All Division 22 Sections
- C. All Division 23 Sections
- D. All Division 26 Sections



## 1.4 TERMS

- A. Acceptable Performance: A component or system being able to meet specified design parameters under actual load including satisfactory documented completion of all functional performance tests, control system trending and resolution of outstanding issues.
- B. Basis of Design: The Contract Documents shall constitute the Basis of Design.
- C. Commissioning Plan: The HVAC Contractor's Commissioning Consultant prepares The Commissioning Plan. *The Commissioning plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process (ASHRAE Guideline 0-2013).* In addition, the Plan defines the scope and format of the commissioning process and the responsibilities of all involved parties. The commissioning team reviews the Commissioning Plan to inform the intent and scope of the commissioning process, to ensure inclusion in the construction project scope/schedule and to facilitate and expedite the commissioning process. The Commissioning Plan is to be distributed by the Commissioning Consultant during the first third of the construction timeframe.
- D. Functional Performance Testing: Is a full range of checkouts and tests carried out to determine if all components, sub-systems, systems and interfaces between systems function in accordance with the Contract Documents and meets the design intent. In this context, "function" includes all modes and sequences of control operation, all interlocks and conditional control responses and all specified responses to abnormal emergency conditions. The Commissioning Consultant will prepare the functional performance tests.
- E. Commissioning (Also Commissioning Process) is a *quality-focused process enhancing the delivery of a project. The process focusses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements. (ASHRAE Guideline 0-2013).* Process to demonstrate The HVAC Contractor that building equipment controls and systems function together properly to meet design intent and performance requirements shown in a composite manner in the Contract Documents.
- F. Resolution Log: The purpose of this document is to provide a method for tracking and resolution of deficiencies discovered during the commissioning process. This list also includes the current disposition of issues and the date of final resolution as confirmed by the Commissioning Consultant. Deficiencies are issues where products, execution or performance does not satisfy the Specifications and/or the design intent. The Commissioning consultant creates and manages the Resolution Log.
- G. Pre-functional Construction Checklists: Commissioning Consultant prepares Checklist for equipment of systems and assemblies. See paragraph 1. A. Checklist shall be for the systems or equipment involved in the commissioning process to verify installation and start-up of equipment is complete and verify that systems are ready for functional testing. These documents require signature by the Contractor prior to continuing with the commissioning process, and are required as a pre-condition of beginning the Functional Performance Testing.
- H. Testing and balancing (TAB) process. A complete pencil copy of TAB reports, on a system-by-system basis, is required prior to the start of any final functional performance test.

## 1.5 DUTIES OF CONTRACTOR

- A. Provide copies of all approved shop drawings, manufacturer's literature, maintenance information or other information as may be needed for systems and assemblies to the Commissioning Consultant.

- B. Collect the information requested by Commissioning Consultant for development of a complete Commissioning Plan, Commissioning Field Notebook, and Functional Performance Tests and provide to the Commissioning Consultant. The **HVAC** Contractor shall review the Commissioning Plan, Commissioning Field Notebook, and Functional performance Test and confirm in writing to the **Engineer** and Commissioning Consultant any known areas of conflict or areas requiring clarifications.
- C. Collect all proposed equipment start-up and Pre-Functional Construction Checklists documentation and place into the Commissioning Field Notebook. The **HVAC** Contractor will provide the Commissioning Consultant with the completed commissioning field notebook.
- D. Provide the Contractor's schedule to the commissioning Consultant for review and comment. Plan for and incorporate commissioning activities into the construction schedule. Provide a sufficient detailed level of scheduling, activity, detail to properly coordinate and schedule the trades. Provide a detailed Commissioning Schedule Fragnet to the project schedule, updated monthly.
- E. Provide Commissioning Consultant with submittals for all systems and assemblies for review and comments. Include submittals of controls system and wiring diagrams and narrative sequences of operation, in time for use in preparing the Functional Test Procedures. The Commissioning Consultant review comments of pertinent submittals is coordinated through the **Engineer**.
- F. Provide a fully operational system per Specifications, started, verified, debugged, calibrated, balanced, tested and under automatic control.
- G. Provide qualified personnel to participate in the commissioning tests, including seasonal testing.
- H. Cooperate with the Commissioning Consultant's personnel.
- I. Provide access to site for the Commissioning Consultant for review, verification and testing activities.
- J. Provide updates to all project documentation to reflect all supplemental instructions, addenda or other revisions to the project construction documents. Updates and architect's supplemental instructions must be posted to the master set of documentation for review and reference by all Contractors and for the Commissioning Consultant's use.
- K. Provide adequate time and resources to perform functional testing of systems and assemblies in contract. These times and activities shall be reflected in the Commissioning Fragnet schedule, updated monthly.
- L. Coordinate participation of all pertinent subcontractors including mechanical, electrical, controls and Testing and Balancing TAB subcontractors in the commissioning process.
- M. Participate in any efforts to finalize sequences of operations with **Engineer**, and Commissioning Consultant.
- N. Verify that coordination, installation, quality control and final testing have been completed such that installed systems and equipment comply with construction documents.
- O. Review the Commissioning Plan, Project Reports and test results and submit comments to the Commissioning Authority.
- P. In a timely manner, address issues identified during construction that may affect the commissioning process or final system performance.

- Q. Perform equipment start-up and testing of mechanical and electrical equipment and systems and document as required with start-up reports and completion of Pre-functional Construction Checklists. These checklists include installation documentation, start-up documentation, controls point-to-point documentation and calibration documentation, verification that controls sequence of operations meets design intent and TAB final documentation. Reports will be stored in the Contractor's field trailer, as a part of the Commissioning Field Notebook. Contractor will coordinate efforts to complete the pre-functional documentation.
- R. Provide preliminary TAB report, indicating all actual field values recorded to the Commissioning Consultant through the **Engineer**, prior to initiation of functional testing. These reports shall be incorporated in the commissioning field notebook. Provide these "pencil copy" TAB data on a system-by-system basis, as systems have been finally and completely balanced.
- S. Pre-test all systems prior to scheduling the final Functional Performance Test for the record. Operate equipment and systems as required in preparation of final functional performance testing. This includes, but is not limited to; manipulating the appropriate controls systems to execute the Functional Test Procedures.
- T. The **HVAC** Contractor shall issue a written Notice of Readiness for each system; include verification of system completion, TAB completion and controls. Provide the Commissioning Consultant a copy of the Notice of Readiness upon completion of all systems works, start-up and Pre-functional Construction Checklists requirements by trade contractors including but not limited to plumbing and electrical contractors.
- U. Participate in the fine-tuning or troubleshooting of system performance, if of these measures becomes necessary.
- V. Review operating and maintenance data for verification, organization, distribution and conformance to requirement of the Contract Documents.
- W. Submit complete operation and maintenance information and as-built drawings to the **Engineer** for compliance review of the requirement of the Contract Documents. Incorporate changes and recommendations provided by the commissioning Consultant into the documentation.
- X. Provide all documentation of training for the systems specified.
- Y. Provide all proprietary test equipment required to test all the systems and equipment in this project. The **HVAC** Contractor shall provide all necessary tools, lifts, ladders, access, PPE and other equipment required for the Commissioning Consultant to witness Functional Performance Testing.
- Z. The Commissioning Field Notebook will be stored in the **HVAC** Contractors field trailer and will be managed by the **HVAC** Contractor. The **HVAC** Contractor shall confirm in writing to the Commissioning Consultant that systems are complete, functional and the appropriate subcontractors have completed the specified tasks and signed off all pre function documentation.
  - 1. Use of an electronic, internet enabled data storage and sharing site is permitted, provided all applicable stakeholders agree to its use, in writing.

## 1.6 DUTIES OF COMMISSIONING CONSULTANT

- A. Develop the Commissioning Plan.
- B. Review the Commissioning Field Notebook with appropriate documentation provided from **HVAC** Contractor. Provide supplemental documentation as necessary to ensure that all aspects of start-up and testing have been complete and documented prior to functional testing.
- C. Develop Functional Test Procedures from Contract Documents and final equipment submittals including narrative sequences of operation, control diagrams and software code for execution with the assistance of **HVAC** Contractor staff as required.
- D. Review the Contractor's submittals relative to the systems and assemblies. Provide comments on the submittals during the same timeframe as the architect / engineer's review. Architect / Engineer have final decision on incorporating comments by the Commissioning Consultant. **Engineer**, formally incorporates the response to the **HVAC** Contractor.
- E. Perform site observations to follow installation progress and to verify system installation quality and readiness for testing.
- F. Observe the start-up activities and initial testing of selected equipment and systems as required and review Contractor's start-up documentation.
- G. Observe or review documentation of validation activities including: Proper test and balance activities, rotating equipment drive alignment, vibration testing, acoustical testing, electrical testing and functional tests for normal and off-normal operating sequences.
- H. Review submittal of all required pre-functional and start-up documentation provided by the **HVAC** Contractor for completeness and reasonableness. This includes installation documentation, start-up documentation, point-to-point checklists and preliminary TAB report, prior to initiation of functional testing.
- I. Witness a random **10%** selection of TAB readings performed by the TAB contractor. Coordinate with Division 23 project specifications. This witnessing activity shall occur during the execution of regular TAB activities.
- J. TAB verification to be a separate activity, occurring prior to the final Functional Performance Testing activities.
- K. Assist with scheduling, direct and witness complete functional testing as defined in the Commissioning Plan and Functional Test Procedures. All testing to be performed and verified by the HVAC, Plumbing or Electrical Contractors as applicable and documented by the Commissioning Consultant.
- L. Witness and verify satisfactory completion of equipment and system tests and inter-systems functional performance tests.
- M. Document inconsistencies or deficiencies in system operations and system compliance. System deficiencies shall be forwarded to the **Engineer**, and documented in the Resolution Log.
- N. Coordinate via the **Engineer**, participation of owner's personnel with equipment, component and systems performance verification and participation in required training.
- O. When commissioning has been successfully completed, recommend acceptance to the **Engineer**, and provide suggestions for those systems not performing as expected.

- P. Complete, certify and submit a Preliminary Commissioning Report that is organized into mechanical, service water heating and lighting controls for independent review. The Report shall include a 2018 International Energy Conservation Code, Section C408.2.4 Preliminary Commissioning Report compliant "Commissioning Compliance Checklist", and shall identify:
1. Itemization of deficiencies found during testing that have not been corrected at the time of report preparation.
  2. Tests deferred because of climatic conditions.
  3. Climatic conditions required for performance of the deferred tests.
  4. Results of functional performance tests.
  5. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.
- Q. After all functional tests are successfully completed and all outstanding issues resolved, the Commissioning Consultant will provide the owner **HVAC Contractor engineer** and architect with a Final Commissioning Report of all commissioning activities that occurred during the project.
- R. Provide technically qualified personnel when scheduled.
- S. The Commissioning Consultant will formally communicate with the **HVAC Contractor** via approved project channels. It is expected, however, that informal communication and coordination will be conducted directly with the subcontractors; records of all contacts will be sent to the Architect through the normal channels.
- T. The Commissioning Consultant is not authorized to release, revoke, alter or expand requirements of Contract Documents, to approve or accept any portion of the work or to perform any duties of the Contractor.

## 1.7 COMMISSIONING PLAN

- A. The Commissioning Plan is a tool through which the commissioning process is described and incorporates the **Engineer** Trade Contractor(s) and Commissioning Authority roles relative to the commissioning process. Commissioning team members are all contractors, subcontractors and design professionals whose participation is of benefit in the delivery of a fully functioning building to the owner. The plan shall describe the communication, authority and responsibility of commissioning team members.
- B. The Commissioning Plan will include the following:
1. The purpose of commissioning.
  2. Detail the commissioning process.
  3. Commissioning team members' responsibilities.
  4. Provide a guideline for acceptance of each piece of equipment or system.
  5. Systems to be commissioned.

## 1.8 COMMISSIONING FIELD NOTEBOOK

- A. The Commissioning Field Notebook is assembled by the **HVAC Contractor** and reviewed by the Commissioning Consultant to identify and track all pertinent commissioning documentation. The **HVAC Contractor** will maintain and manage completion of this Notebook. The Notebook provides a central location for the Commissioning Consultant to identify and organize all pertinent information and will include the following format:
1. Summary describing Notebook contents and use.
  2. Commissioning Plan for contractor field reference.

3. Listing of all specification documentation requirements listed by specification section, with construction completion sign offs for appropriate parties. These types of documents include piping pressure testing, flushing reports, factory start-up reports and any field-testing relative to the project.
  4. Copy of final approved submittal / shop drawings for each major piece of equipment involved in commissioning, as well as systems such as controls.
  5. Tabs for each specification section with copies of completed, signed off pre-functional checklists and final Functional Performance Tests.
  6. Commissioning project reports, resolution logs schedule information or any other documentation provided by the Commissioning Consultant.
  7. Provide a .pdf copy of entire completed Commissioning Field Notebook to Commissioning Consultant at conclusion of project for use in developing final Commissioning Report, prepared by the Commissioning Consultant.
- B. Internet enabled data sharing applications will be considered for use on this project as the Field Notebook provided the **HVAC** Contractor or Commissioning Consultant bear the cost for such application, and all stakeholders agree to its use.

## 1.9 SYSTEMS TO BE COMMISSIONED

- A. Systems and Equipment to Be Functionally Tested: The system features are to be functionally tested and other building features will be evaluated for installation quality during construction. The functional performance testing will include the following systems and equipment.
1. Mechanical Systems:
    - a. Outside air units
    - b. Rooftop units
    - c. Pumps
    - d. Building automation system

## 1.10 COMMISSIONING ACTIVITIES

- A. The Commissioning Fragnet Schedule: This schedule defines the milestones and conditions that must be achieved before system testing and other commissioning activities can commence. The schedule also includes the expected duration of the various tasks so that the commissioning process can be incorporated into the overall construction schedule.
- B. Commissioning Field Notebook: The **HVAC** Contractor is required to create, develop and maintain the Commissioning Field Notebook. The **HVAC** Contractor shall identify and track all pertinent commissioning documentation required during the installation start-up and checkout phases in the Commissioning Field Notebook. The Commissioning Notebook will be kept by the **HVAC** Contractor on site and will be made available to all subcontractors for their use. The Notebook provides a central location for the subcontractors and Commissioning Consultant to identify, copy, and organize all pertinent information.
- C. Preparation for Testing: To prepare for the system performance testing, the Commissioning Consultant will examine the design and Construction Documents, and develop detailed Functional Test Procedures and data forms. **The** Contractor must verify that the systems they install comply with the Construction Documents and are fully functional.

- D. Commissioning is not intended to be a testing or inspection function that replaces any of the Contractors' obligations for testing and proof of performance. Functional testing will only begin when **the contractor confirms to the Commissioning Consultant in writing that all systems intended to be commissioned are readied for functional testing**, the TAB process is complete for both air and water balancing, and the controls are completed and all control loops properly tuned.
- E. Functional Testing: Functional testing is performed by experienced and qualified technicians of the Contractor(s), responsible for installation as facilitated by the Commissioning Consultant and may be observed by other members of the commissioning team including the Owner. Functional testing will verify proper sequencing, operation and performance of installed equipment and systems under realistic operating conditions. The functional testing will follow with written Functional Test Procedures with test results documented for permanent record.
- F. Documentation: In addition to the Functional Test Procedures, written documentation will be maintained for all other commissioning activities. Project communication reports shall be issued by the Commissioning Authority to the Contractor and key members of the commissioning team to document apparent deficiencies identified during examination of design and construction documents, daily activities on-site, construction deficiencies and successful or unsuccessful functional test results. At the end of the commissioning process, all documentation will be assembled and summarized in the Final Commissioning Report.
- G. Deficiency Resolution: When an Issues Log, Resolution Log or Field Report is issued to address an identified deficiency, the Contractor shall forward the reports to the appropriate parties to initiate corrective action in an expeditious manner. The designer is relied on for supplemental instructions or design modifications and issuance of final design details and the Contractors are relied on for implementation of that design. Change orders must be issued through proper contract channels.

## 1.11 FUNCTIONAL TEST PROCEDURES

- A. The Functional Test Procedures include, but are not limited to, the following:
  - 1. Verification that all HVAC and service water heating equipment is installed in a serviceable manner for maintenance.
  - 2. Verification of all equipment's ability to perform to the design intent.
  - 3. Verification of the performance of sub-systems consisting of combinations of equipment (e.g., refrigeration cycle, pumps and interconnecting piping).
  - 4. Verification of the performance of the automatic controls in all seasonal modes.
  - 5. Verification of the performance of the HVAC system as a whole.

## PART 2 - PRODUCTS (NOT USED)

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Operating equipment and systems shall be tested in presence of the Commissioning Consultant **and Engineer** to demonstrate compliance with specified requirements.
  - 1. Notify the **Owner** in writing, fourteen (14) days prior to tests, twenty-one (21) days prior if a utility shutdown is required, scheduled under requirements of this Section.

2. Testing shall be conducted under specified design operating conditions as recommended or approved by the **Engineer**.
  3. The Functional Performance Testing shall be completed by the Contractor as a requirement of Substantial Completion. The acceptance of Functional Performance Test by **Engineer** is a requirement of Final Completion.
- B. All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these Specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each sub-system, followed by entire system, followed by interaction with other major systems.
  - C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the installing contractor. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Commissioning Consultant in the commissioning process.
  - D. Acceptance Documentation: A copy of the functional performance tests results shall be necessary acceptance documentation along with other specified requirements. Documentation must be signed and dated.

### **3.2 ACCEPTANCE PROCEDURES**

- A. Prior to functional performance testing of each system, the Commissioning Consultant shall observe and verify that the physical installation of components and systems being tested is substantially installed in accordance with the Contract Documents.
- B. Contractor's Tests:
  1. System shall be checked for proper installation, shall be adjusted and calibrated to verify that it is ready to function as specified.
  2. All system elements shall be checked to verify that they have been installed properly and that all connections have been made correctly.
  3. All discrete elements and sub-systems shall be adjusted and checked for proper operation.
  4. Start-up and operational tests shall be complete, signed and submitted for review by Commissioning Consultant within five (5) days of each activity, prior to starting functional performance testing.
- C. The functional performance testing process shall be accomplished for all equipment, sub-systems, systems and system interfaces. The order of functional performance testing shall be reflected in the Commissioning Fragnet Schedule. All must be tested for acceptances and there shall be a separate checklist for each to ensure documentation specific to each is complete.
- D. Each system shall be operated through all modes of system operation (e.g., occupied, unoccupied, warm-up, cool-down, etc., as applicable) including every individual interlock and conditional control logic, all control sequences, both full-load and part-load conditions and simulation of all abnormal conditions for which there is a specified system or controls response. The warm-up and cool-down test shall be a performance test, as applicable.
- E. Temporary upsets of systems, such as distribution fault, control loss, set-point change, equilibrium upset and component failure, shall be imposed at different operation loads to determine system stability and recovery time.



- F. When the functional performance of all individual systems has been proven, the interface or coordinated responses between systems shall be checked. The systems involved may be within the overall HVAC work or they may involve other systems, such as emergency systems for life safety.
- G. **Corrective Measures:** If acceptable performance cannot be achieved, the cause of the deficiency will be identified. If it is determined, that the deficiency was caused by the system or component not being installed per the manufacturer's recommendations or Contract Documents, the necessary corrective measures shall be carried out by the installing Contractor. Every check or test for which acceptable performance was not achieved shall be repeated after the necessary corrective measures have been completed. This re-testing process should be repeated until acceptable performance is achieved. The Contractor will be allowed one retest after initial testing of the equipment. If the retest fails, the Contractor shall be financially responsible, at standard rates, to reimburse the Commissioning Consultant for the additional time taken to achieve acceptable performance.

### **3.3 TRAINING AND INSTRUCTION**

- A. Training and instruction of Owner personnel is a part of the commissioning process and essential for the proper operation of the facility. The contractors and vendors providing the training will complete training plans and submit to the Commissioning Consultant for review and approval in conjunction with the **Engineer**.

### **3.4 SCHEDULE**

- A. The following schedule reflects the probable expected sequence and duration for the various tasks, so that the commissioning process can be integrated with the general construction schedule and refined over the course of the project. Actual sequencing and durations shall be by the General Contractor and Sub-Contractors, coordinated with the Commissioning Consultant.

- B. Note: Attention to these scheduling needs is important to prevent conflicts that have been problematic within the commissioning process:

Milestone	Duration	Successor	Predecessor
Commissioning Kick off Mtg.	1 day	All contractors on board including Controls and TAB	Before major MEP installation
Review equipment submittals	2 weeks	After receipt of submittals	Before ordering or installation
Develop Pre-functional Construction Checklists	2 weeks	After equipment submittal review and after receipt of O&M literature	Before MEP installation
Walk contractors through Pre-functional Construction Checklists	1 day	After development of Pre-Functional Checklist documentation	Before MEP installation
Write Functional Tests	3 to 5 weeks	After controls submittal review	3 weeks prior to functional testing
Submit Functional Tests for review by COTR and Contractors	1 week	After development of Functional Tests	Before Functional testing
Complete Pre-functional Construction Checklists (contractor task)	On Going	During installation, startup and test, adjust and balance	Before TAB Backcheck and functional testing
Site Observations (CxA)	on-going	After majority of MEP installation	Before TAB Backcheck and functional testing
Test, Adjust and Balance (Contractor task)	See CPM schedule	After Start-up and Pre-functional Construction checks. All walls, windows, doors, ceilings must be installed.	Before TAB Backcheck
Test, Adjust and Balance Backcheck (10%)	1 week	After Start-up and receipt of completed Pre-functional Construction Checklists from contractors	Before functional testing
Functional Testing	2 months	After TAB Backcheck and receipt of completed Pre-functional Construction Checklist have been completed by contractors	Before Government occupancy
Issues Resolution	1 week	After Functional Testing	Before Government occupancy
Final Commissioning Documentation Submittal	2 weeks	After resolution of issues log	2 weeks after resolution of issues log

## COMMISSIONING COMPLIANCE CHECKLIST

Project Information: \_\_\_\_\_ Project Name: \_\_\_\_\_

Project Address: \_\_\_\_\_

Commissioning Authority: \_\_\_\_\_

Commissioning Plan (Section C408.2.1)

- ☐ Commissioning Plan was used during construction and includes all items required by Section C408.2.1
- ☐ Systems Adjusting and Balancing has been completed.
- ☐ HVAC Equipment Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: \_\_\_\_\_
- ☐ HVAC Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: \_\_\_\_\_
- ☐ Economizer Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: \_\_\_\_\_
- ☐ Lighting Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: \_\_\_\_\_
- ☐ Service Water Heating System Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: \_\_\_\_\_
- ☐ Manual, record documents and training have been completed or scheduled
- ☐ Preliminary Commissioning Report submitted to owner and includes all items required by Section C408.2.4

I hereby certify that the commissioning provider has provided me with evidence of mechanical, service water heating and lighting systems commissioning in accordance with the 2018 IECC.

Signature of Building Owner or Owner's Representative \_\_\_\_\_ Date \_\_\_\_\_

**END OF SECTION 23 0801**

## SECTION 23 0900 - AUTOMATIC TEMPERATURE CONTROL 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### 1.2 SUMMARY

- A. This Section includes control equipment for all HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

#### 1.3 WORK INCLUDED

- A. Automatic Temperature Control (ATC) Subcontractor shall:
  - 1. Furnish and install controls necessary to tie the new HVAC equipment into the existing Johnson Controls Metasys building automation system (BAS); UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and operator interface.
    - a. Operator interface shall be provided via web-based access.
    - b. Electronic actuation shall be employed.
    - c. Provide a complete graphics package that includes all automatic temperature control system points and allows for easy adjustment.
  - 2. Provide a complete DDC temperature control system as specified herein.
  - 3. Provide all power wiring, control wiring, and conduit for all DDC panels, Programmable Controllers, programmable controllers and DDC temperature control devices, except as detailed within. Provide all electrical work associated with the BAS control system and as called for on the Drawings including:
    - a. Providing all line voltage and low voltage power wiring and conduit in accordance with all local codes, the National Electric Code (latest edition), and Division 26.
      - 1) Run power circuits from normal/emergency power panel(s) when present, and normal power panels in buildings where no back-up or emergency power generator exists. Equip each control panel enclosure with battery back-up UPS equipment.
    - b. Providing all line voltage and low voltage control wiring, concealed in conduit or exposed as plenum-rated cable, in accordance with local codes, the National Electric Code (latest edition), and Division 26.
      - 1) Run power circuits from normal/emergency power panel(s) when present, and normal power panels in buildings where no back-up or emergency power generator exists. Equip each control panel enclosure with battery back-up UPS equipment.

- 2) All low voltage electrical control wiring throughout the building shall be as described in Part 3 of this Section.
  - c. Incorporating and providing surge transient protection in design of system to protect electrical components in all DDC Controllers, Programmable Controllers, and operator interface devices.
  4. The ATC Subcontractor shall hardwire from each duct mounted smoke detector to its associated supply and/or return fan. Fan shutdown via software is not acceptable. Provide all wiring and conduit required.
    - a. Control circuit shall de-energize fans in the 'Hand', as well as the 'Auto', position.
    - b. DDC system shall monitor all duct detectors.
  5. Furnish all automatic air dampers, including actuators. Provide all power wiring, conduit and controls for automatic air dampers installed.
  6. Furnish and install all airflow monitoring devices.
  7. Furnish all control valves. Provide control wiring and conduit, and any power wiring and conduit (if necessary), for each control valve.
  8. Provide a field technician to coordinate work with the Testing and Balancing technicians.
  9. For all exhaust fans, provide all interlock power/control wiring and conduit between the fan and its motorized damper.
  10. Program initial occupied/unoccupied schedules and weekday/weekend/holiday time schedules for each HVAC equipment item and system. Coordinate with the Owner to determine the schedule parameters to be input.
  11. Program initial trends for each HVAC equipment item and system. Coordinate with the Owner to determine the points to be trended on each system and the duration of the trends, along with any other required parameters associated with each particular trend.
  12. Perform functional performance testing for all controls installed.
- B. The HVAC Trade shall:
1. Install all automatic air (outdoor air, return air, exhaust air, ventilation air) control dampers furnished by the ATC Subcontractor.
  2. Install all control valves furnished by the ATC Subcontractor.
  3. Install all openings for all airflow monitoring devices, flow switches and alarms furnished by the ATC Subcontractor.
  4. Install all control devices, alarms and monitoring devices for all air and water systems required by the Drawings and the Specifications that is not installed by the ATC Subcontractor.
  5. Mount/install all duct mounted smoke detectors furnished by the Electrical Contractor.
  6. Provide all required access doors.
- C. The Electrical Trade will:
1. Furnish all duct or unit mounted smoke detectors, and provide power wiring and fire alarm control wiring to these smoke detectors. Detectors shall be provided with alarm contacts for use by the DDC system.
  2. Provide a minimum of two (2) 120-volt, 20-amp breakers in each normal/emergency power panel for use by the ATC Subcontractor.

## 1.4 DEFINITIONS

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- D. MS/TP: Master slave/token passing.
- E. PC: Personal computer.
- F. PID: Proportional plus integral plus derivative.
- G. RTD: Resistance temperature detector.

## 1.5 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
  - 1. Graphic Display: Display graphic with minimum **20** dynamic points with current data within 10 seconds.
  - 2. Graphic Refresh: Update graphic with minimum **20** dynamic points with current data within 8 seconds.
  - 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
  - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
  - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
  - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
  - 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
  - 8. Reporting Accuracy and Stability of Control - report values and maintain measured variables within tolerances as follows:
    - a. Water Temperature: Plus, or minus 1°F.
    - b. Water Flow: Plus, or minus 5 percent of full scale.
    - c. Water Pressure: Plus, or minus 2 percent of full scale.
    - d. Space Temperature: Plus, or minus 1°F.
    - e. Ducted Air Temperature: Plus, or minus 1°F.
    - f. Outside Air Temperature: Plus, or minus 2°F.
    - g. Dew Point Temperature: Plus, or minus 3°F.
    - h. Temperature Differential: Plus, or minus 0.25°F.
    - i. Relative Humidity: Plus, or minus 5 percent.
    - j. Airflow (Pressurized Spaces): Plus, or minus 3 percent of full scale.
    - k. Airflow (Measuring Stations): Plus, or minus 5 percent of full scale.
    - l. Airflow (Terminal): Plus, or minus 10 percent of full scale.
    - m. Air Pressure (Space): Plus, or minus 0.01-inch wg.
    - n. Air Pressure (Ducts): Plus, or minus 0.1-inch wg.
    - o. Carbon Dioxide: Plus, or minus 50 ppm.

## **1.6 SEQUENCE OF OPERATION**

- A. Refer to Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls" for required operating sequences for each HVAC system, equipment item and component.

## **1.7 GENERAL PRODUCT DESCRIPTION**

- A. The building automation system shall consist of the following:
  - 1. Stand-alone Application Specific DDC Controllers (PRCs).
  - 2. DDC Network Panel.
- B. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Programmable Controllers and operator devices.
- C. 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 control strategies at other operational devices.
- D. The DDC system hardware and software installed for this project must maintain compatibility with systems developed in the future. It is a requirement that the ATC Subcontractor support this "Forward and Backward Compatibility" claim with written company literature and local references of facilities where the company's former DDC system ties into their current DDC system.

## **1.8 QUALITY ASSURANCE**

- A. Materials and equipment shall be the catalogued products of the manufacturer. The ATC Subcontractor personnel shall have been regularly engaged in production and installation of automatic temperature control systems for a minimum of 5 years. The control system shall be the manufacturer's latest standard design that complies with the specification requirements.
- B. Install system using competent workers who are regularly employed and fully trained by the ATC Subcontractor in the installation of temperature control equipment. The ATC shall provide adequate staff to engineer, supervise, program and commission the control system in a timely manner. In addition, ATC shall maintain fully equipped service trucks to provide full warranty service available 24 hours a day, 7 days a week with a minimum 4-hour response time.
- C. Single source responsibility of supplier shall be the complete installation and proper operation of the BAS and control system and shall include debugging and proper calibration of each component in the entire system.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Electronic equipment shall conform to the requirements all government regulations.

## 1.9 SUBMITTALS

### A. Manufacturer's Product Data including:

1. Hardware--cutsheets, product descriptions, and engineering information.
2. Engineering--design requirements for initial installations and/or additions to existing systems.
3. Installation--mounting and connection details for field hardware, accessories, and central site equipment.
4. Field hardware set-up, checkout, and tuning techniques.
5. Central site set-up, software loading, and checkout techniques.

### B. Shop Drawings

1. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work. Shop drawings shall include the following:
  - a. Bill of materials of equipment indicating quantity, manufacturer, and model number.
  - b. Schematic flow diagrams of:
    - 1) Each controlled HVAC central system showing pumps, dampers, valves, and control devices.
    - 2) Each controlled HVAC equipment item showing components fans, coils, dampers, valves, and control devices.
  - c. Complete wiring diagrams showing all power, signal, and control wiring. Include wire types.
  - d. Details of control panel faces, including controls, instruments, and labeling.
  - e. Written description of sequence of operation.
  - f. Schedule of dampers including size, leakage, and flow characteristics. Include damper size and type, actuator type, torque and damper actuator part numbers.
  - g. Schedule of valves including flow characteristics. Include valve size and type, actuator type, torque and valve actuator part numbers.
  - h. Points list for each HVAC system or HVAC equipment item being controlled.
  - i. Tag number of devices and any other details required to demonstrate that the system will function properly.
2. Shop drawings shall clearly indicate intended sequence of operation for all equipment.
3. For DDC system include configuration diagrams showing all panel types and locations. Submittal data shall include descriptions of software, calculations, communications network and workstations. Submit software flowcharts or program printouts to verify compliance with specifications. Include the overall point's list. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-built" graphic software flow diagrams herein required by this specification.
4. Shop drawings shall include a list of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
5. Scaled drawings showing the location of all wall mounted DDC panels, wall mounted sensors, and similar devices.

### C. Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Architect/Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.



D. Project Specific User Manual to be provided at time of training:

1. System reference material shall contain as a minimum, an overview of the system, its organization, the concepts of networking and central site/field hardware relationships as well as the following:
  - a. Activating the central site
  - b. Central site screen menus and their definitions
  - c. Establishing setpoints and schedules
  - d. Uploading and downloading software, setpoints, schedules, operating parameters and status between the central site and field hardware
  - e. Collecting trend data and generating trend plots
  - f. Enabling alarms and messages
  - g. Report generation
  - h. Backing up software and data files
  - i. Using the central site with 'third party' software
2. Software Documentation:
  - a. Shall contain a listing of the alarm and message conditions, which may be detected for each piece of controlled equipment and the standard alarm and message texts, which can be displayed when those conditions exist.
  - b. A graphic flow diagram for each software application program provided as part of this project.
  - c. Graphics generation.
  - d. At the completion of the project and after final acceptance of the system, the ATC Subcontractor shall provide a complete backup of all system software on CD. Include:
    - 1) Final "As-Built" version of graphics
    - 2) Final "As-Built" version of DDC controller programming

## 1.10 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1. Submit operation and maintenance data under provisions of Division 01.
2. Include systems descriptions, set points, and controls settings and adjustments.
3. Include inspection period, cleaning methods, recommend cleaning materials, and calibration tolerances.
4. Provide owner instruction under provisions of Division 01. Use operation and maintenance data as a training manual.

B. Graphics

1. Submit screen captures of control graphics for each system and each equipment item for approval.

## 1.11 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Division 01.
- B. Include systems descriptions, set points, and controls settings and adjustments.
- C. Include inspection period, cleaning methods, recommend cleaning materials, and calibration tolerances.

- D. Provide owner instruction under provisions of Division 01. Use operation and maintenance data as a training manual.

#### **1.12 SEQUENCING, SCHEDULING, AND COORDINATION**

- A. Coordinate work under provisions of General and Supplementary Conditions, Division 01 and Division 23, and ensure system is completed and commissioned by Date of Substantial Completion.
- B. Coordinate installation of system components with installation and checkout of mechanical systems equipment such as rooftop units, etc.

#### **1.13 WARRANTY**

- A. Base Bid: All devices and components shall be warranted for a period of two (2) years following the date of final acceptance by the Owner. The warranty period shall not start until all systems under project are accepted by the Owner. No partial warranty shall be permitted.
  - 1. This warranty shall include all labor and material. Any defects arising during the warranty period shall be corrected without cost to the Owner. During the warranty period, the contractor's service personnel shall be available to be physically present at the facility within twenty-four (24) hours for emergency repairs.

#### **1.14 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 equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

#### **1.15 COORDINATION**

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with Owner and Architect before installation. Obtain approval for final locations from Owner and Architect prior to installation.

### **PART 2 - PRODUCTS**

#### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Johnson Controls Metasys (furnished and installed by JCI Pittsburgh located at 117 Technology Drive, Pittsburgh, PA).
- B. Johnson Controls Metasys (furnished and installed by OZ Enterprises located at 60 Abele Road, Suite 1101, Bridgeville, PA 15017).
- C. Johnson Controls Metasys (furnished and installed by Johnson Controls Inc. located at 1044 N Meridian Rd. Suite A, Youngstown, OH 440509).

## **2.2 GENERAL**

- A. The Owner shall have full rights to all programming software and to all passwords.
- B. All DDC controllers must have proportional-integral (PI) or proportional-integral-derivative (PID) algorithms incorporated into their programming.
- C. Control signals from the Building Automation System (BAS) to all controlled components must be the analog type signal. Pulse signals, or floating point control signals, are not acceptable.
- D. All DDC controls shall be fully BACNet compatible and shall be EtherNet compatible.

## **2.3 WEB-BASED ACCESS TO BAS**

- A. Provide a web-based interface to allow Owner the capability of bi-directional access to the new Building Automation System (BAS). The system shall support unlimited users using standard web browsers such as Internet Explorer. The web server software shall operate on standard industry PC servers. Proprietary servers or "black boxes" are not acceptable. Web browser software shall be manufactured by the control system manufacturer and shall have the same look and feel as the operating system.
- B. For Local Area Network installations provide access to the control system via the Internet. The owner shall provide a connection to the Internet via high-speed cable modem, ADSL, ISDN, T1 or through the facility ISP. The owner shall pay for all monthly Internet access fees and connection charges.
  - 1. The Division 23 contractor shall be responsible for providing communications cabling and outlets from the nearest IDF to the BAS network connection location(s).
  - 2. LAN cabling shall be CAT6 or greater. Comply with requirements of the owner's contract requirements for local area network installation.
    - a. If the Division 23 contractor cannot comply with the qualification requirements set forth in the owner's contract requirements for local area network installation, then the Division 23 contractor shall subcontract the installation and testing of communications cabling to a qualified installer.
- C. Web-based features shall include:
  - 1. Access to the BAS using workstation browsers, cell phones, and portable computers.
  - 2. Complete control of system operating parameters, such as schedules and setpoints, from virtually any modern communications device inside or outside of the building.
  - 3. The ability to use secure socket layers (SSL), wireless-access-protocol devices, digital subscriber lines, virtual private networks, and other emerging network architectures and technologies that are being developed for the entire Web community.
  - 4. Ability to monitor and control the EMS through any computer with web browser software and Internet or network access, not only certain computers running proprietary software.
  - 5. Reuse existing graphics for web pages or automatically generate web pages utilizing the same tools that are used to engineer the control system graphics. The web pages must be in sync with the actual control system. Systems in which the web pages must be hand crafted separately and which will have a different look than the EMS graphics will not be acceptable.
  - 6. Provide built-in firewall security to protect network. Use industry standard encryption of all communications between the web-based interface and the user.

D. Web Browser Clients:

1. System shall support web clients using a standard Web browser such as Internet Explorer, , etc.
2. Web browser software shall run on Microsoft Windows platforms.
3. Web browser shall provide the same view of the system, in terms of graphics, logs, alarms, and provide the same interface methodology as is provided by the HMI.
4. Web browser client shall support at a minimum, the following functions:
  - a. User log-on identification and password shall be required. If unauthorized user attempts access the log-on screen is re-displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
  - b. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
  - c. Storage of graphical screens shall be in the Web Server without requiring any graphics to be stored on the client machine.
  - d. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
  - e. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    - 1) Modify common application objects, such as set points, in a graphical manner.
    - 2) Commands to start and stop binary objects shall be done by clicking or double clicking, the selected object and selecting the appropriate command from the pop-up menu.
    - 3) View logs, charges, and trend reports.
    - 4) View and acknowledge alarms.
  - f. Loading of additional software at the web-client is not acceptable. This must be performed via upload from the web-server.
  - g. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.
5. Tower Engineering shall be provided with full web browser client access including web address and all passwords with owner's approval.

## 2.4 DDC NETWORK PANEL

- A. Each Network Panel shall have sufficient memory to support its own operating system and databases, including: Control processes; Energy management applications; Alarm management applications including custom alarm messages for each level alarm for each point in the system; historical/trend data for points all hardwired I/O points and all set-points; maintenance support applications; custom processes; operator I/O; web-based communications; and manual override monitoring.
- B. DDC Network Panel shall provide at least two RS-232C 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. DDC Network Panel shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.
- C. Network Panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

- D. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- E. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC 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 72 hours.
  - 1. Upon restoration of normal power, the DDC controllers shall automatically resume full operation without manual intervention.
  - 2. Should DDC controller's memory be lost for any reason, the user shall have the capability of reloading the DDC controllers via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
- F. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.
- G. DDC Network Panel shall have the ability to perform any or all the following energy management routines:
  - 1. Time-of-day scheduling, Calendar-based scheduling, Holiday scheduling, temporary schedule overrides
  - 2. Start-Stop Time Optimization, Automatic Daylight Savings Time Switchover, Night setback control
  - 3. Economizer switchover Fan speed/CFM control
  - 4. Peak demand limiting, Temperature-compensated duty cycling
- H. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a cell phone or pager.
- I. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Network Panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the 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.
- J. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points identified by the Owner. The ATC Subcontractor shall trend all hardwired I/O points as well as all set points.
  - 1. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 4 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.
- K. DDC Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis. DDC Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off.

- L. DDC Network Panel shall provide optimal start/stop feature that integrates schedules and DDC controller setpoints and temperatures to optimize setpoint temperatures with occupancy and un-occupancy modes. Must include adaptive modeling to self-correct by using historical data of thermal characteristics of building.
- M. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password. Provide a minimum of 5 levels of access control.
- N. Reports shall be generated and directed to workstation displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
  - 1. A general listing of all points in the network.
  - 2. List of all points in alarm, in override status, locked out, disabled.
  - 3. DDC Controller trend overflow warning.
  - 4. List all weekly schedules and holiday programming.
  - 5. List of limits and dead bands.
- O. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
  - 1. Add/delete/modify stand-alone DDC Network Panels, Programmable Controllers, PC interface.
  - 2. Add/delete/modify points of any type and all associated point parameters, tuning constants, control loops, custom control processes.
  - 3. Add/delete/modify alarm reporting definition, energy management applications, totalization, historical data trending.
  - 4. Add/delete/modify time and calendar-based programming, graphic displays, operator passwords.
- P. Provide automatic web-based and dial-up communications as specified. Automatic dial-up communications shall include the following features as a minimum:
  - 1. Dial-Out - Manual dial-out to cell phones and pagers shall be accomplished using only a mouse to select and request the desired remote connection.
- Q. Communications cards:
  - 1. Communications cards shall be provided and employed as the means of communications between all DDC control panels and Programmable Controllers.

## 2.5 PROGRAMMABLE CONTROLLERS (PRC)

- A. Each PRC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each PRC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- B. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide each central system controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM or a minimum of 72-hour battery backup shall be provided. All programs shall be field-customized to meet the user's exact control strategy requirements.

- C. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.
- D. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.
- E. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:
  - ◆ Accuracy:  $\pm 0.5^{\circ}\text{F}$
  - ◆ Operating Range:  $35^{\circ}$  to  $115^{\circ}\text{F}$
  - ◆ Set Point Adjustment Range:  $55^{\circ}$  to  $95^{\circ}\text{F}$
  - ◆ Set Point Modes: Independent Heating, Cooling, Night Setback-Heating, Night Setback-Cooling
  - ◆ Calibration Adjustments: None required
  - ◆ Installation: Up to 100 feet from Controller
- 1. 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. In lieu of an internal jack, provide a separate terminal jack mounted on a stainless steel wall plate adjacent to the sensor to facilitate direct access to the controller via the terminal.
- 2. Each room sensor shall also include the following auxiliary devices: Setpoint Adjustment Dial, Temperature Indicator, and Override Switch.
  - a. The setpoint adjustment dial shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at a web-based workstation, DDC Controller, or via the portable operator's terminal.
  - b. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, DDC Controller or via the portable operator's terminal.
- 3. Provide flush-mount type sensors for all rooms. These shall be Siemens model 540-520 or equivalent.
- 4. Coordinate the final check-out of the terminal units with the Testing and Balancing Subcontractor.
- F. Each controller shall perform its primary control function independent of other DDC controller or if communication is interrupted. Reversion to a fail-safe mode of operation during communications interruption is not acceptable. The controller shall receive its real-time data from the DDC Network Panel time clock to insure continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings.

## 2.6 FIELD DEVICES AND EQUIPMENT

- A. Temperature Sensors: Temperature transmitters shall be 2-wire, averaging or single point 1000 OHM platinum RTD element with  $\pm .5$  degrees accuracy. Room sensors and immersion type sensors shall be the single point type. Duct sensors shall be the averaging type, nickel element, 17 ft. in length evenly strung across the face area of the duct.
1. For units with space sensor or space thermostat, provide the following:
    - a. Temperature display showing actual measured temperature and setpoint.
    - b. Setpoint adjustment switch for a minimum of  $\pm 3$  degrees of adjustment.
    - c. Override switch to allow switching from unoccupied to occupied mode for a timed period programmed by software.
  2. Room Sensor and Room Thermostat Accessories:
    - a. Thermostat and Sensor Covers: For all thermostats.
    - b. Insulating Bases: For thermostats located on exterior walls.
    - c. Thermostat and Sensor Guards: Metal wire guard mounted on separate base for thermostats and sensors located in public areas. Cast aluminum guard with cast aluminum base plate shall be similar to Johnson Controls model GRD10A-601.
    - d. Adjusting Key: As required for device.
- B. Liquid and Steam Temperature Sensors (RTD), Commercial Grade
1. Description:
    - a. Platinum with a value of 100 or 1000 ohms at 0°C and a temperature coefficient of 0.00385 ohm/ohm/degree C.
    - b. Encase RTD in a stainless steel sheath with a 0.25-inch OD.
    - c. Sensor Length: 4, 6, or 8 inches as required by application.
    - d. Process Connection: Threaded, NPS 1/2.
    - e. Two-stranded copper lead wires.
    - f. Powder-coated steel enclosure, NEMA 250, Type 4.
    - g. Conduit Connection: 1/2-inch trade size.
    - h. Performance Characteristics:
      - 1) Range: Minus 40° to 210°F.
      - 2) Interchangeable Accuracy: Within 0.54°F at 32°F.
- C. Thermowells - Commercial Grade
1. Stem: Straight shank formed from solid bar stock.
  2. Material: Brass stainless steel.
  3. Process Connection: Threaded, NPS 3/4.
  4. Sensor Connection: Threaded, NPS 1/2.
  5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
  6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
  7. Length: 4, 6, or 8 inches as required by application.
  8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.



D. Non-DDC Thermostats

1. Electric Low Limit Duct Thermostat (Freezestat): Snap-acting, double pole, double throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint, requiring minimum 20 feet length of bulb. Provide one thermostat for every 20 sq. ft.
2. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type with heat anticipator, integral manual Auto-Off selector switch subbase. UL listed for electrical rating.

E. Other Electronic Sensors

1. Current Sensing Relays: Provide current status switch for pump and fan status. Must be able to detect belt loss and motor failure. Switch shall be 100% solid state and have adjustable setpoint from 1 to 135 Amps. Veris Industries Hawkeye model H-708 or equivalent.
2. Humidity Sensors: bulk polymer sensor element. Multiple signal and power output including 4-20 ma, 0-10vDC; loop and 24v power.
  - a. Space RH Transmitter: With locking cover to match room sensors.  $\pm 3\%$ , accuracy from 5 to 95% RH.
  - b. Duct and Outside Air RH Transmitter: With element guard and mounting plate.  $\pm 3\%$  accuracy from 5 to 95% RH.
3. Carbon Dioxide Sensor and Transmitter:
  - a. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - 1) Kele, model KCD-W-V.
    - 2) Digital Control Systems, model 308 WC.
    - 3) Air sense, Model 310e.
  - b. Sensing Technology: Non-dispersive, infrared.
  - c. Measurement Range: 0-2000 ppm.
  - d. Accuracy: 3% of reading; or  $\pm 40$  ppm + 2% of reading.
  - e. Repeatability:  $\pm 20$  ppm.
  - f. Calibration Interval: 5 years.
4. Pressure Switches: Install differential pressure switches across each bank of pre-filters and final filters at each air handling unit for status indication.
5. Velocity, Differential, and Static Pressure Sensors:
  - a. Pressure sensors shall be Setra, Modus or equal. The sensors shall have a 0 to .25" w.g. range for space applications and they shall have a range of 0 to 1" W.G. or 0 to 5" w.g. for duct applications unless noted otherwise. The range of the sensor shall be 10 to 25 percent above maximum (negative or positive) for fan control.
  - b. Air Velocity Sensors: The air velocity transducer shall utilize both a velocity sensor and a temperature sensor to accurately measure air velocity (in SFPM, standard feet per minute). The built-in temperature sensor shall automatically correct the flowrate for temperature variations. Both sensors shall be rugged glass-coated platinum resistance detectors (RTDs). The circuit shall heat the velocity sensor to a constant temperature differential above ambient temperature and shall measure the cooling effect of the air flow providing excellent low velocity sensitivity and high accuracy.

- c. The sensor shall have a negligible pressure drop. The mass flowrate in SCFM (standard cubic feet/minute) shall be obtained by multiplying the SFPM velocity indicated by the by the sensor by the cross-sectional area of the duct in square feet. Accuracy of the sensor shall be 1.5% FS at room temperature. The sensor shall have a 4 to 20 mA output.
- d. The sensors shall provide a 4 to 20 milli-amp output and they shall have an end-to-end accuracy of  $\pm .25\%$  with repeatability of 0.5%.
- e. Differential Pressure Transmitters:
  - 1) General air and water pressure transmitter requirements shall be as follows:
    - a) Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
    - b) Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
    - c) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
    - d) A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
  - 2) Building differential air pressure applications (-1" to +1" w.c.):
    - a) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
    - b) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
      - -1.00 to +1.00 w. c. input differential pressure ranges (Select range appropriate for system applications).
      - 4-20 mA output
      - Maintain accuracy up to 20 to 1 ratio turndown
      - Reference accuracy: +02.% of full span.

#### F. Airflow Measurement System

##### 1. General:

- a. Airflow measurement devices (AMDs) shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
- b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
- c. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate. Actual airflow rate calculations shall have the capability of being field adjusted by the transmitter for altitudes other than sea level.

- d. Temperature output shall be field configurable to provide either the velocity-weighted duct average temperature or simple arithmetic average temperature.
- e. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.
- f. Excluded Devices:
  - 1) Vortex shedding airflow measurement devices.
  - 2) Pitot tubes, pitot arrays, piezo-rings and other differential pressure measurement devices
  - 3) Measurement technologies using "chip-in-glass", "chip-in-epoxy" or other "chip" type thermistors for the heated sensor component are not acceptable.

2. Main Ducts Application:

a. Sensor Probes:

- 1) Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube.
- 2) Sensor probe mounting brackets shall be constructed of 304 stainless steel.
- 3) Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper. PVC jacketed internal wiring is not acceptable.
- 4) Probe internal wiring connections shall consist of solder joints and spot welds. Connectors of any type within the probe are not acceptable. Printed circuit boards within the probe are not acceptable.
- 5) Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
- 6) Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392°F and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable.
- 7) Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
- 8) Each sensor probe shall contain one or more independently wired sensing nodes.
- 9) Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
- 10) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
- 11) Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
- 12) Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
- 13) The number of independent sensor nodes provided shall be as follows:

Area ft <sup>2</sup> [m <sup>2</sup> ]	# of Sensor Nodes
≤ 0.5 [≤ 0.047]	1
> 0.5 & ≤ 1 [≤ 0.093]	2
> 1 & ≤ 2 [> 0.093 & ≤ 0.186]	4
> 2 & ≤ 4 [> 0.186 & ≤ 0.372]	6
> 4 & ≤ 8 [> 0.372 & ≤ 0.743]	8

> 8 & ≤ 12 [ $> 0.743$ & $\leq 1.115$ ]	12
> 12 & ≤ 14 [ $> 1.115$ & $\leq 1.30$ ]	14
> 14 [ $> 1.30$ ]	16

- a) A total of 4 probes shall be required for openings with an aspect ratio  $\leq 1.5$  and with an area  $\geq 25 \text{ ft}^2$  ( $\geq 2.32 \text{ m}^2$ ).
- b. Transmitter:
- 1) A remotely located microprocessor-based transmitter shall be provided for each measurement location.
  - 2) The transmitter shall be comprised of a main circuit board and interchangeable interface card.
  - 3) All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
  - 4) All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
  - 5) All receptacle plug pins shall be gold plated.
  - 6) The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
  - 7) The transmitter shall be capable of providing a high and/or low airflow alarm.
  - 8) The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
  - 9) The transmitter shall be provided with a 16-character, alpha-numeric, LCD display. The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.
  - 10) The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one isolated RS-485 (field selectable BACnet MS/TP or Modbus) network connection.
  - 11) Analog output signals shall provide the total airflow rate and be field configurable to output one of the following:
    - a) temperature
    - b) airflow alarm
    - c) system status alarm
  - 12) Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.
  - 13) Provide a Bluetooth low energy interface card and software capable of viewing/modifying all transmitter setup parameters, transmitter diagnostics and running the field adjustment wizard via an Android or iOS phone or tablet. The software shall be capable of capturing and displaying the average airflow and temperature of the device and the airflow and temperature of each sensor node. The software shall allow for setup parameters and airflow/temperature data to be saved on the phone or be emailed to a specified client
  - 14) The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
  - 15) The transmitter shall use a "watchdog" timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

- c. Performance:
  - 1) Each sensing node shall have an airflow accuracy of  $\pm 2\%$  of reading over an operating range of 0 to 5,000 FPM.
  - 2) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
  - 3) Each sensing node shall have a temperature accuracy of  $\pm 0.15^{\circ}\text{F}$  over an operating range of  $-20^{\circ}\text{F}$  to  $160^{\circ}\text{F}$ .
- d. Listings and Certifications:
  - 1) The AMD shall be UL873 Listed as an assembly. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
  - 2) The AMD shall be BTL Listed.
- e. Manufacturer: Ebtron model GTx116-P+ as represented by Specified Solutions Inc., (412) 346-1200.

3. Fan Inlet Application:

- a. Sensor Probes:
  - 1) Each sensor probe shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
  - 2) Sensor node internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
  - 3) Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from  $-67^{\circ}\text{F}$  to  $392^{\circ}\text{F}$  and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable.
  - 4) Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
  - 5) Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
  - 6) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
  - 7) Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
  - 8) Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
  - 9) The number of independent sensor nodes provided shall be as follows:
    - a) SWSI and DWDI fans: 2 probes x 1 sensor node/per probe in each fan inlet. Ebtron Model GTC108-F, HTA 104-F or HTN 104-F
    - b) Fan Arrays (2 to 4 fans): 2 probes x 1 sensor node per probe in each fan inlet. Ebtron Model GTC 108-F
    - c) Fan Arrays (5 to 8 fans): 1 probe x 1 sensor node per probe in each fan inlet. Ebtron Model GTC 108-F

- d) EBTRON models HTA104-F or HTN104-F shall be acceptable substitutes for single SWSI or DWDI fan applications when approved, and when the following capabilities are not needed for this project.
  1. Multiple fan measurements with one transmitter.
  2. Gold plated cable pins and receptacles.
  3. Combined analog and network output capabilities

b. Transmitter:

- 1) A remotely located microprocessor-based transmitter shall be provided for each measurement location.
- 2) The transmitter shall be comprised of a main circuit board and interchangeable interface card.
- 3) All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
- 4) All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
- 5) All receptacle plug pins shall be gold plated.
- 6) The transmitter shall be capable of determining the average airflow rate and temperature of each fan. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
- 7) The transmitter shall have startup firmware to facilitate setup of multiple fans and fan areas.
- 8) The transmitter shall be capable of providing a high and/or low airflow alarm.
- 9) The transmitter shall be capable of providing individual fan alarming on fan array configurations.
- 10) The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
- 11) The transmitter shall be provided with a 16-character, alpha-numeric, LCD display. The total airflow rate, temperature, airflow alarm, individual fan alarm and system status alarm shall be visible on the display.
- 12) The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection.
- 13) Analog signal capability shall include two output terminals: the first, shall provide the total airflow rate; while the second output shall be field configurable to provide one of the following:
  - a) temperature
  - b) airflow alarm
  - c) individual fan alarm; or
  - d) system status alarm
- 14) Network communications shall provide: the total airflow rate, average temperature, individual fan airflow rates, individual fan temperatures, airflow alarm, individual fan alarm, system status alarm, individual sensor node airflow rates, individual sensor node temperatures and fan inlet area.
- 15) The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
- 16) The transmitter shall use a "watchdog" timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

- c. Performance:
  - 1) Each sensing node shall have an airflow accuracy of  $\pm 2\%$  of reading over an operating range of 0 to 10,000 FPM. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
  - 2) Each sensing node shall have a temperature accuracy of  $\pm 0.15^\circ \text{F}$  over an operating range of  $-20^\circ \text{F}$  to  $160^\circ \text{F}$ .
- d. Listings and Certifications:
  - 1) The AMD shall be UL873 Listed as an assembly. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
  - 2) Any AMD network-capable model supplied with BACnet protocol shall be BTL Listed.
- e. Manufacturer: Ebtron model GTx108-F, HTA104-F or HTN104-F as specified in paragraph 3.a.9 as represented by Specified Solutions Inc, 412-346-1200.

G. Pressure Independent Control Valves

- 1. General:
  - a. Control valves shall be factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
  - b. Close-Off Pressure Rating: Bubble-tight shutoff (no leakage) at the close-off pressure required for the application and its location in the system in which the valve is installed. It shall be the responsibility of the ATC Subcontractor to determine the required close-off pressure rating for each control valve.
- 2. Sizing:
  - a. Hydronic:
    - 1) Two-Position: Line size or size using a pressure differential of 1 psi.
- 3. Pressure Independent Control Valves (Water Coil Optimization):
  - a. NPS 2 and Smaller: Forged brass body rated at no less than 250 PSI, chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc.
  - b. NPS 2-1/2 through 6: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.
  - c. Accuracy: The control valves shall accurately control the flow from 0 to 100% rated flow with an operating pressure differential range of 5 to 50 PSI differential across the valve with a valve body flow accuracy of  $\pm 5$  total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis
  - d. Flow Characteristics: Equal percentage characteristic.

- e. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
  - f. Water coil optimization shall be accomplished by utilizing a pressure independent control valve assembly; two temperature sensors providing feedback of coil inlet and outlet water temperatures; and an electronic flow meter to provide analog flow feedback. Software shall control the valve to avoid the coil differential temperature from falling below a programmed set point. The valve assembly shall be capable of accepting an analog signal representing the coil power required. Real-time data and configuration of valve operating parameters shall be available by means of BACnet MS/TP, BACnet/IP or HTTP. Monitored points shall include but not be limited to inlet and outlet coil water temperatures, absolute flow, absolute valve position, absolute coil power and total heating/cooling energy in BTU/hr. Configuration points shall include but not be limited to valve, flow, and power settings. Historical trend data shall be stored for up to 13 months and be retrievable in a standard time-stamped format.
  - g. The manufacturer shall provide a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).
  - h. A wet calibrated electronic flow meter shall provide dynamic feedback to measure flow and verify performance.
  - i. The control valve shall require no maintenance and shall not include replaceable cartridges.
4. Characterized Control Ball Valves:
- a. 3" and Smaller: Nickel-plated forged brass body rated at no less than 400 psi, stainless steel ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL or stainless steel flow characterizing disc.
  - b. 2-1/2" through 6": GG25 cast iron body, ANSI 125, class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring package design, PTFE seats, and a stainless steel flow characterizing disc.
  - c. Valve assemblies shall be maintenance free.

#### H. Valve Actuators

- 1. Size for torque required for damper seal at maximum design conditions and valve close-off pressure for system design.
- 2. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle; directly couple and mount to the valve bonnet stem; or ISO-style direct-coupled mounting pad.
- 3. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
- 4. Overload protected electronically throughout rotation.
- 5. Fail Safe Operation: Mechanical fail safe shall incorporate a spring-return mechanism. Electronic fail safe shall incorporate an active balancing circuit to maintain equal charging rates among the super capacitors with a visual indication of the fail-safe status on the actuator face, and with the following:
  - a. Power fail position field adjustable between 0 to 100% in 10-degree increments
  - b. A 2-second operational delay, field adjustable between 0 and 10 seconds
  - c. Capability of changing the fail-safe position through an integrated switch without removing the mounted actuator.
- 6. Power Requirements: 24-volts AC/DC or 120-volts AC



7. Proportional Actuators shall be software configurable through an EEPROM without the use of actuator mounted switches. Programmable functions shall include a scalable operating range from 0.5 - 32.0 volts DC with a 2.0-volt DC (min) span; variable runtime; and data logging.
8. Temperature Rating: -22°F to +122°F
9. Housing: NEMA type 2 for indoor locations and NEMA type 4X for outdoor locations.
10. Actuator shall be UL listed.
11. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
12. Provide binary valve position feedback contacts for 2-position valves and analogue valve position feedback contacts for modulating valves.

## **2.7 CONTROL PANEL ENCLOSURES**

- A. Control panel enclosures shall be NEMA 1 enclosures constructed of minimum 16-gauge steel or minimum 14-gauge aluminum. Control panel enclosures shall have a perforated metal subpanel for mounting of control components and panels. Control panel enclosures shall have a hinged door and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION - GENERAL**

- A. Install in accordance with manufacturer's instructions.
- B. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Also, confirm locations of thermostats, humidistats, and other exposed control sensors with Architect and/or Owner prior to rough-in. Install devices 48 inches above the floor to comply with ADA requirements.
  1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- C. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors. Provide sun shield for sensing element.
- D. Provide separable sockets for liquids and flanges for air bulb elements.
- E. Locate all control panel enclosures within mechanical or electrical equipment rooms.
  1. Consideration may be given to locating control panel enclosures in spaces other than mechanical or electrical equipment rooms that are typically unoccupied, such as Storage Rooms, Janitor Closets, etc. The ATC Subcontractor must coordinate and obtain approval for each proposed location with the Architect and/or Owner prior to installation.
  2. Under no circumstances shall control panel enclosures be installed in finished rooms or rooms intended for occupancy unless such locations are specifically requested by the Owner.
- F. Install guards on thermostats in the following locations:
  1. Entrances.
  2. Stairwells.
  3. Public corridors.
  4. Public restrooms.
  5. Other public areas.

- G. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- H. Connect and configure equipment and software to achieve sequence of operation specified.
- I. Mount compressor and tank unit on restrained spring isolators with 1-inch static deflection. Vibration isolators are specified in Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment." Isolate air supply with wire-braid-reinforced rubber hose. Secure and anchor according to manufacturer's written instructions and seismic-control requirements.
  - 1. Pipe manual and automatic drains to nearest floor drain.
  - 2. Supply instrument air from compressor units through filter, pressure-reducing valve, and pressure relief valve, with pressure gauges and shutoff and bypass valves.
- J. Install automatic air dampers where required by Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls."
  - 1. Install standard automatic air dampers in supply airstreams and return airstreams where both sides of the damper will be exposed to conditioned air.
  - 2. Install low temperature thermally broken automatic air dampers in exhaust airstreams, outdoor airstreams and relief airstreams where one side of the damper will be exposed to ambient conditions or unconditioned air.
- K. Install damper motors on outside of duct in warm areas only. Do not install damper motors in locations exposed to outdoor temperatures.
- L. Install hydronic instrument wells, valves, and other accessories in accordance with Division 23 Section 23 2113 "Hydronic Piping."

### **3.2 AIRFLOW MEASUREMENT SYSTEM INSTALLATION**

- A. Install airflow measurement systems (measuring stations) in locations specified in Division 23 Section 23 0993 "Sequence of Operations for HVAC Control."
- B. Install airflow measuring stations in accordance with manufacturer's placement guidelines. A written report shall be submitted to the Architect and Engineer if any discrepancies are found.
- C. Adjusting:
  - 1. The airflow measuring stations shall not be adjusted to match field measurements without approval from the Architect or Engineer when installations do not comply with the manufacturer's suggested placement guidelines. Field adjustment, when required, shall be accomplished using transmitter firmware that calculates adjustment gain and offset coefficients based on one or two reference measurements. Adjustment of the signal value in the host controller is discouraged.

### **3.3 CONTROL VALVE INSTALLATION**

- A. Install control valves where required by Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls."
  - 1. Install pressure independent control valves as follows:

- a. On the outlet of each heat pump water coil for air handling units OAU-1 through OAU-4 and RTU-1 through RTU-6.
2. Install standard control valves in all locations requiring a control valve except at the hot water and chilled water coils of the air handling units identified above.

### **3.4 WIRING INSTALLATION**

- A. Run all line voltage control wiring in conduit in accordance with the National Electric Code and the requirements specified in Division 26, Sections "Basic Electrical Requirements;" "Basic Electrical Materials and Methods;" "Raceways;" "Wires and Cables;" "Cabinets, Boxes, and Fittings;" "Supporting Devices;" and "Electrical Identification."
- B. Power for controls shall be obtained from the nearest normal/emergency power panel.
- C. All low voltage power wiring shall be as described below:
  1. Provide "plenum-rated" cable for low voltage wiring.
    - a. Except where otherwise prohibited by applicable codes, conductors and cables operating at less than 30 volts and having "plenum type" insulation listed for compliance with NEC Article 300-22(c) are permitted to be installed without raceways above accessible suspended acoustic ceilings. Accessible suspended ceilings are defined as those having access panels, un-splined tiles for access purposes, and unclipped lay-in tiles for access purposes, or other approved access means at intervals of not more than 20 feet from one another.
    - b. Where conductors or cables are installed in compliance with the above, the cables shall be neatly supported clear of the ceiling system by means of approved pre-formed nylon tie devices. Supports shall be accessible. Maintain a minimum spacing of than 18" between parallel runs of control wiring and wiring of other systems.
  2. Run control wiring in EMT conduit in Mechanical rooms and other exposed wall and ceiling locations.
- D. Connect manual-reset limit controls independent of manual control switch positions.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

### **3.5 MANUFACTURER'S FIELD SERVICES**

- A. Commission and start control systems. Use attached Commissioning Forms and submit completed forms to Owner and Engineer before training and final punchlist.

### **3.6 ADJUSTING**

- A. Calibrating and Adjusting
  1. Calibrate instruments.
  2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
  4. Control System Inputs and Outputs:
    - a. Check analog inputs at 0, 50, and 100 percent of span.
    - b. Check analog outputs using milli-ampere meter at 0, 50, and 100 percent output.
    - c. Check digital inputs using jumper wire.
    - d. Check digital outputs using ohmmeter to test for contact making or breaking.
    - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
  5. Flow:
    - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    - b. Manually operate flow switches to verify that they make or break contact.
  6. Pressure:
    - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
  7. Temperature:
    - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    - b. Calibrate temperature switches to make or break contacts.
  8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
  9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
  10. Provide diagnostic and test instruments for calibration and adjustment of system.
  11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Setup the occupied/unoccupied DDC equipment time schedules based upon time schedules. Setup the initial occupied/unoccupied system temperature and humidity setpoints. Setup the initial local temperature adjustment ranges. Coordinate with the Owner to establish the initial values for schedules, setpoints, and ranges.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide a minimum of two (2) visits to Project during other than normal occupancy hours for this purpose.

### 3.7 DEMONSTRATION

- A. Provide all verification testing prior to functional performance testing.
- B. Provide systems demonstration under provisions of Division 01.

- C. Demonstrate complete operation of systems including Sequence of Operation after Date of Substantial Completion. The Owner or his appointed representative shall be given the opportunity to witness the functional performance testing and the successful demonstration of the operating sequences. The ATC Subcontractor shall provide the Owner or his appointed representative a minimum of 14-days notice prior to functional performance testing. Also, the ATC Subcontractor shall provide the Owner or his appointed representative a minimum of 14-days notice prior to demonstration of the operating sequences.

### **3.8 ON-SITE TESTING**

- A. Provide Engineer-approved operation and acceptance testing of the complete system. Complete Functional Test Checklist as outlined at end of this section for each piece of mechanical equipment controlled by ATC on this project. The Engineer, the Owner, and/or Owner representative may witness all tests and shall be given sufficient notice prior to any tests being conducted.
- B. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Provide a detailed cross-check of each sensor within the system by making a comparison between the reading at the sensor and a standard traceable to the National Bureau of Standards.
- C. Provide a cross-check of each control point within the system by making a comparison between the control command and the field-controlled device. For each DDC Controller test DDC software sequence to confirm a match with design sequence. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Submit the results of functional and diagnostic tests and calibrations to the Engineer for final system acceptance as shown on Functional Test Checklist.
- D. Compliance Inspection Checklist: Submit the requested items of information to the Owner's Representative and Architect/Engineer for verification of compliance to the project specifications. Failure to comply with the specified information shall constitute non-performance of the contract. The Subcontractor shall submit written justification for each item in the checklist that he is unable to comply with. The Owner's Representative and the Architect/Engineer will initial and date the checklist to signify Subcontractor's compliance before acceptance of system.

### **3.9 SERVICE AND GUARANTEE**

- A. General Requirements: Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of two years after completion of successful performance test. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work. Without additional cost, provide software upgrades issued during the warranty period.
- B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates, transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.
- C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
- D. Emergency Service: Owner will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 8 hours after receiving a request for service. Restore the control system to proper operating condition within 24 hours.

- E. Operation: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.
- F. Systems Modifications: Provide any recommendations for system modification in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior approval of Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.
- G. Software: Provide all software updates during the warranty period and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.

### **3.10 TRAINING**

- A. The ATC Subcontractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. It is the intent of the Owner to become thoroughly versed in the operation and programming of the DDC system so as to make full use of system capabilities and be able to revise graphics. All information and documentation necessary to do this work must be provided.
  - 1. Provide 40-hours of on-site training for Owner's operating personnel. Split training into minimum five (5) 8-hour sessions to be completed during the period of warranty. Coordinate/Schedule training sessions with the Owner a minimum of 14-days in advance. Training shall include:
    - a. Explanation of drawings, operations, and user manuals
    - b. Walk-thru of the job to locate control components
    - c. Explanation of manual and automatic control devices
    - d. DDC Controller and PRC operation/function
    - e. Operation of operator's terminal, Central computer workstation and laptop computer
    - f. Hands on training of Central computer workstation menus and commands to include fully functioning system
    - g. Operator control functions including graphic generation and field panel programming
    - h. Explanation of maintenance manuals
    - i. Explanation of adjustment, calibration, and replacement procedures
- B. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, the ATC Contractor must make additional training available. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training.
- C. Prepare the following checklist for each piece of mechanical equipment that is controlled by ATC DDC. Refer to Division 01 Section "Commissioning Requirements" for additional requirements.

## Functional Test Checklist

FT-\_\_\_\_

Includes installation and wiring checkout, sensor and device calibration, and functional performance testing.

### 1. Participants

Party	Participation	Date
_____	_____	_____
_____	_____	_____
_____	_____	_____

- *The checklist items are all successfully completed.....* ☐ YES ☐ NO

### 2. Installation Checks

Check if okay. Enter comment or note number if deficient.

For each Terminal Unit

Check	Equip Tag->						Notes
Air Systems							
Fans and Dampers							
Filter pressure differential measuring device installed and functional (magnehelic, inclined manometer, etc.).							
Dampers close tightly and all dampers (OSA, RA, EA, etc.) stroke fully without binding and spans calibrated and BAS reading site verified.							
All damper linkages have minimum play.							
Low limit freeze stat sensor located to deal with stratification & bypass.							
Variable Speed Drive operating properly.							
Electrical and Controls							
Safeties in place and operable							
Control system interlocks installed and functional							
Smoke detectors in place							
All control devices and wiring complete.							
Specified point-to-point checks have been completed.							
Specified sequences of operation and operating schedules have been implemented with all variations documented							

### 3. Sensor and Actuator Calibration

For each Terminal Unit

Sensor or Actuator & Location	Location OK	1st Gauge or BAS Value	Instr. Meas'd Value	Final Gauge or BAS Value	Pass Y/N?
DAT					
RAT					
Space Temp					
etc					

Sensor & Location	Location OK	1st Gauge or BAS Value	Instr. Meas'd Value	Final Gauge or BAS Value	Pass Y/N?

### 4. Device Calibration Checks. The actuators or devices listed below must be checked for calibration.

Device or Actuator & Location	Procedure / State	1st BAS Value	Site Observation	Final BAS Reading	Pass Y/N
Main OSA damper position**	1. Closed				
	2. Full open				
Return air damper position **	1. Closed				
	2. Full open				

### 5. Functional Performance Testing Record

Use one test record for each RTU, etc containing DDC Controller by ATC.

Seq. ID	Mode ID	Test Procedure (including special conditions)	Expected Response	Pass Y/N	Note
	FAN OFF	Standby Check. With Units Commanded off by BAS.	Verify by visual inspection that: Return Air Dampers in AHU are Open and Outside Air Dampers and Relief Dampers are Closed, Cooling Coil Valve is Closed, Hot Water Coil - Valve is Open.		
	UNIT STARTUP	With Units Commanded on by BAS.	Supply Fan Starts.		
	TEMPERATURE CONTROL ENTHALPY/ECONOMIZER	1. Utilizing BAS, Record OSA & RA Temp. and OSA & RA Humidity. 2. Calculate Enthalpy of OSA. 3. Utilizing Enthalpy calculations, modulate dampers such that Enthalpy of OSA is less than Enthalpy of Return Air at revised conditions.	Outdoor Air Dampers and Return Air Dampers should modulate to maintain Enthalpy/Economizer setpoint. Cooling Coil Valves should be closed.		
	DISCHARGE AIR OR SPACE TEMPERATURE	Modulate heating and/or cooling to maintain setpoint.	Verify that AHU System maintains setpoint by modulating/staging HVAC equipment.		
	DISCHARGE TEMPERATURE RESET	If reset required, test at different temperatures. Utilizing BAS Trend Logging, at 6 min intervals and record DAT setpoint, DAT.	Verify that Discharge Air Temperature Setpoint is reset at increments according to programmed time intervals to maintain schedule.		



Seq. ID	Mode ID	Test Procedure (including special conditions)	Expected Response	Pass Y/N	Note
	SMOKE CONDITIONS	Interfacing with EC, simulate a fire mode with the Fire Alarm System.	Verify that AHU System returns to FAN OFF Status, with OSA and Relief Dampers in a Closed Position.		
	WARMUP CONTROL	Place Units' BAS Control Mode into Warm-up. Overwrite RAT Sensor Reading to be 65°F. Then overwrite RAT Sensor Reading to be 72°F.	Verify that dampers assume a 100% Return Air Mode. Then verify that unit returns to Normal Operation Mode.		
	FREEZE CONDITION	Simulate a low temperature condition at low limit detection thermostat of below 35°F.	Verify that system alarms, fan stop, OSA Dampers close, RA dampers open and Heating Valve Opens.		
	FILTER DROP	Reset the Filter Differential Pressure to exceed the setting recommended by the filter manufacturer.	Verify that the BAS reports an alarm.		
	REVIEW	Review schedules, current setpoints and sequences with Sequence of Control and Control Drawings prepared by ATC.	Submit approved differences to be incorporated into As-Built.		

- END OF TEST -

**END OF SECTION 23 0900**

## **SECTION 23 0993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

#### **1.3 DEFINITIONS**

- A. DDC: Direct digital control
- B. ATC: Automatic Temperature Control
- C. BAS: Building Automation System
- D. AI: Analog Input
- E. AO: Analog Output
- F. DI: Digital Input
- G. DO: Digital Output
- H. VAV: Variable air volume
- I. VF: Variable Frequency
- J. AHU: Air Handling Unit
- K. RTU: Rooftop Unit
- L. CO<sub>2</sub>: Carbon Dioxide

#### **1.4 MISCELLANEOUS REQUIREMENTS**

- A. The control strategies described in this section shall be used in conjunction with the Input/Output Summary Tables attached herein for engineering the control systems and preparing the required control drawings.

- B. The Input/Output Summary Tables and the sequence have been made to complement one another. The ATC Contractor shall interpret the sequences and the Input/Output Summary Tables such that if a device is called for in one and not the other, it will be treated as if called for in both.
- C. Control of all HVAC equipment shall be through the DDC system and by electric control as specified per individual sequence.
- D. Whether indicated or not, all temperature setpoints included in the sequences of this Section shall be adjustable.

## **PART 2 - PRODUCTS**

- 2.1 Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for control equipment and devices.

## **PART 3 - EXECUTION**

### **3.1 GENERAL REQUIREMENTS**

- A. The following general applications software shall be required on all appropriate equipment [i.e. rooftop units, exhaust fans, terminal unit equipment, etc.] for the purpose of optimizing energy consumption while maintaining occupant comfort:
- B. Time of Day Scheduling [TOD]: The system shall be capable of the following scheduling features:
  - 1. Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times [hours: minutes]. A weekly repeating schedule, i.e., between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule, not five.
  - 2. Dated schedules shall be entered up to 9 [nine] years in advance.
  - 3. Schedules shall be self-deleting when effective dates have passed.
  - 4. Leap years shall be adjusted automatically without operator intervention.
  - 5. For maximum speed in the communication of schedules, the operator shall have the ability to communicate schedules at the most efficient level with one scheduling command through the mouse interface. This ranges from system wide to individual zones, groups or pieces of equipment.
  - 6. The system shall allow the operator to designate any combination of equipment to form a group that can be scheduled with a single operator command through the mouse interface at the workstation. Any designated group shall have the capability to be a member of another group.
  - 7. The operator shall be able to make all schedule additions, modifications and deletions using the mouse and appropriate dialog boxes. In addition, the operator shall have the capability to edit all schedules off line and then download any or all schedule changes to the control modules with a single operator command through the mouse interface. In the event that a schedule in the control module is different from the workstation, the operator shall have the capability to upload any or all schedules from the control module to the workstation.
  - 8. The operator shall be able to view a color-coded forecast of schedules for instant overview of facilities schedules. Schedule graphic forecast shall include colored coded indication of all types of schedules, i.e., normal, holiday and override.

- C. Optimum Start/Stop [OSS]/Optimum Enable/Disable [OED]:
1. Provide software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in  $\text{øF}/\text{hour}$  of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.
- D. Day/Night Setback [DNS]:
1. The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the DNS range and shall remain activated until the space temperature returns to the DNS range.
  2. The system shall be capable of closing all outside air and exhaust air dampers during the unoccupied period, except for 100% outside air units.
  3. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room in the building if full DDC control is not being affected.
  4. User shall be able to define, modify or delete the following parameters.
    - a. DNS setpoint temperature[s]
    - b. Temperature band for night heating operation
    - c. Period when the DNS is to be activated
- E. Timed Local Override [TLO]:
1. The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button [momentary contact], wind-up timer, or ON/OFF switches as detailed in the I/O summary.
  2. If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse and the total maximum ON time permitted. Override time already entered shall be canceled by the occupant at the input point. If a wind-up timer is used the equipment will stay in override mode until the timer expires. Year to date, month-to-date and current day override history shall be maintained for each TLO input point. History data shall be accessible by the operator at any time and shall be capable of being automatically stored on hard disk and/or printed on a daily basis.
- F. Space Temperature Control [STC]: There shall be two space temperature setpoints, one for cooling and one for heating, separated by a dead band. Only one of the two setpoints shall be operative at any time. The cooling setpoint is operative if the actual space temperature has more recently been equal to or greater than the cooling setpoint. The heating setpoint is operative if the actual space temperature has more recently been equal to or less than the heating setpoint. There are two modes of operation for the setpoints, one for the occupied mode [example: heating =  $72^{\circ}\text{F}$  or cooling =  $76^{\circ}\text{F}$ ] and one for the unoccupied mode [example: heating =  $55^{\circ}\text{F}$  or cooling =  $90^{\circ}\text{F}$ ].
- G. The occupied/unoccupied modes may be scheduled by time, date, or day of week.
1. If the actual space temperature is in the dead band between the heating setpoint and the cooling setpoint, the color displayed shall be green for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
  2. If the space temperature rises above the cooling setpoint, the color shall change to yellow.
  3. When space temperature falls below the heating setpoint, the color shall change to light blue.

4. All setpoints and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.
5. When comfort conditions are warmer than ideal, indicated by the color yellow a request for additional cooling shall be sent over the network to other cooling equipment in the HVAC chain, such as a chiller. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.
6. When comfort conditions are cooler than ideal; indicated by the color light blue, a request for additional heating shall be sent over the network to other heating equipment in the HVAC chain, such as a boiler. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.
7. The cooling [and heating] setpoints may be increased [decreased] under demand control conditions to reduce the cooling [heating] load on the building during the demand control period. Up to three levels of demand control strategy shall be provided. The operator may predefine the amount of setpoint increase [decrease] for each of the three levels. Each space temperature sensor in the building may be programmed independently.
8. An optimum start-up program transition from the unoccupied setpoints to the occupied setpoints. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope [AI: Space Temperature].
9. A PID control loop, comparing the actual space temperature to its setpoint, shall modulate the dampers [and heating coil valve or heating stages in sequence] to achieve the setpoint target.

### 3.2 GLOBAL CONTROL VALVE OPERATION

- A. Provide a DDC global control valve point or software program override index signal to enable/ disable the heat pump condenser water system control valves. This operation shall allow all the control valves in the hot water system to be positioned full open for balancing.

### 3.3 VENTILATION OPTIMIZATION

- A. The **OAU and RTU** outdoor-air damper shall be controlled to deliver required outdoor airflow at all load conditions during the occupied mode. The outdoor airflow setpoint for each **OAU and RTU** shall be as scheduled on the Drawings or shall be as indicated in its sequence of operations contained in this Section. The actual outdoor airflow shall be sensed at the outdoor air intake.
- B. The building DDC system shall include a time-of-day schedule to indicate whether the **OAU and RTU** is in the occupied mode or the unoccupied mode. When the schedule indicates that the **OAU and RTU** is in the unoccupied mode, the required outdoor airflow for the system shall be zero. When the schedule indicates that the **OAU and RTU** is in the occupied mode, the required outdoor airflow for the **OAU and RTU** shall equal the design minimum outdoor airflow rate, unless one of the following is true:
  1. The **RTU** serves one or more zones or spaces equipped with a carbon dioxide [CO<sub>2</sub>] sensor.
    - a. For those zones equipped with a CO<sub>2</sub> sensor, the required outdoor airflow for the zone shall be continuously calculated using the measured CO<sub>2</sub> concentration as an indicator of the current per-person ventilation rate.
  2. Ambient conditions are such that the **OAU and RTU** is operating in the economizer mode.

- C. If an OAU or **RTU** serves one or more zones or spaces equipped with a CO<sub>2</sub> sensor the DDC system shall modulate the outdoor air and return air dampers as follows:
1. If the CO<sub>2</sub> level in all spaces containing CO<sub>2</sub> sensors is below setpoint, then the outdoor air damper shall be placed in its low occupancy minimum outdoor position. The low occupancy minimum outdoor air position for each RTU is indicated in the **OAU and RTU** Schedule on the Drawings or is indicated in its sequence of operations contained in this Section.
  2. If the CO<sub>2</sub> level in any space rises above setpoint, then the DDC system shall increase the unit's outdoor air quantity in 1% increments every 30 seconds until all space CO<sub>2</sub> levels are 50 ppm [adjustable] below their setpoint or the high occupancy minimum outdoor air position is reached.
  3. If the CO<sub>2</sub> level in all spaces is below setpoint, the DDC system shall reduce the unit's outdoor air quantity in 1% increments every 30 seconds until any space CO<sub>2</sub> level rises to within 25 ppm [adjustable] of its setpoint or the unit's low occupancy outdoor air position is reached.
- D. The CO<sub>2</sub> setpoint in each space shall be one of the following:
1. An Owner determined setpoint.
  2. A DDC determined setpoint that is 500 ppm above the outdoor air CO<sub>2</sub> concentration level as measured and averaged by two CO<sub>2</sub> sensors.
- E. The DDC system shall not request a quantity of outdoor air that is above the **OAU and RTU** high occupancy minimum outdoor air position/quantity unless the current outdoor air temperature and humidity conditions permit economizer use and a system need for cooling exists.

### 3.4 **A2L REFRIGERANT MONITORING SYSTEM**

- A. Any rooftop unit or air handling unit system that contains A2L refrigerants of a sufficient volume shall be supplied with refrigerant monitoring system integral to the unit. Where these monitoring systems exist, provide the following sequence:
1. When the monitoring system detects refrigerant of a sufficient concentration:
    - a. Deactivate compressor(s).
    - b. Activate the supply fan.
    - c. An alarm message shall be sent to the DDC control system to indicate that the refrigerant monitoring system detected refrigerant.

### 3.5 **HEAT PUMP WATER SYSTEM**

- A. The building heat pump water system shall be controlled via the building DDC system and each boiler's integral controller. The ATC Subcontractor shall provide DDC control components to accomplish the sequence described below.
- B. The ATC Subcontractor shall provide all field labor to install all sensors shipped loose by the manufacturers. In addition, the ATC Subcontractor shall provide all field labor, wiring and conduit to connect all sensors shipped loose.
- C. The ATC Subcontractor shall provide controls necessary for the DDC system to perform the following:

D. During Occupied mode, lead circulating pump (P-3 or P-4) for the indoor heat pump circulating loop shall remain on continuously. VFD shall operate pump to maintain pressure at system transducer. During unoccupied mode, pump shall energize upon a call for compressor use from any building heat pump. Provide a 60 second delay between pump start and energize of compressor(s).

- E. The speed of the building loop pumps shall be modulated to maintain a differential loop pressure at a point in the system approximately 2/3 the distance from the building loop pumps to the most remote heat pump unit.
- F. During School Occupied mode – the two-way, two position valves for each classroom pod shall be open. During Summer Mode, these valves shall close unless there is a call for cooling or dehumidification.
- G. During Occupied mode, lead wellfield circulating pump (P-1 or P-2) shall remain on continuously. During unoccupied mode, pump shall energize only on a drop in heat pump loop temperature below 35°F (adjustable) or rise above 85°F (adjustable).
- H. Pumps 1 and 2 are operated in lead / standby manner. Pumps 3 and 4 are also operated in a lead/standby manner. One pump shall start and, if it fails for 30 seconds, the standby pump shall automatically start. The signal to the lead pump shall de-energize.
- I. Each building-loop pump and each wellfield loop pump shall be provided with a variable frequency drive. Unlike the building pumps, the wellfield pumps shall not vary once its speed is determined through the water balancing operation. The wellfield pumps shall operate at constant speed and the variable frequency drives shall be used for balancing purposes only.
- J. Glycol Feed Tank [GFT]:
  - 1. Connect to the GFT dry contact and sense a tank low level condition. Send an alarm to the DDC system operator's console and send a text message to the Owner's service technician when this condition occurs.
  - 2. Provide 4-20mA connection to GFT system pressure connection. Display pressure on DDC system operator's console. If pressure in the system drops 40% [adjustable] below setpoint, send an alarm to the DDC system operator's console and send a text message to the Owner's service technician.
- K. The ATC Subcontractor shall provide break glass switches at each exit door. The switches shall be wired to de-energize the boilers and domestic hot water heaters when the switches are in an alarm condition.
- L. DDC Points List for Heating System:
  - 1. AI Outside Air Temperature
  - 2. AI GFT System Pressure
  - 3. AI Heat Pump Loop Remote Differential Pressure [located at 2/3 distance from pump to remote outlet]
  - 4. AI Wellfield loop differential pressure. Mounted in the mechanical room.
  - 5. AO Variable Speed signal to Building Pumps [Each Pump]
  - 6. AI Wellfield Heat Pump Loop Return Temperature
  - 7. AI Wellfield Heat Pump Loop Supply Temperature
  - 8. AI HPR Heat Pump Loop Return Temperature
  - 9. AI HPS Heat Pump Loop Supply Temperature
  - 10. AI OA Temperature
  - 11. DI Pump Status (each)

### 3.6 PACKAGED ROOFTOP OUTSIDE AIR UNIT OAU-1 to OAU-4

- A. The constant air volume [CAV] rooftop unit [RTU] shall be controlled via DDC type controls to accomplish the sequence described in this article.
- B. The CAV RTU consists of an outside-air damper, a return air damper, a heat recovery device, a gas fired heating section, heat pump compressor with refrigerant based heating and cooling coil, a refrigerant hot gas reheat coil, a supply fan with variable frequency [VF] drive, an exhaust fan with VF drive. ALL actuators shall be electronic. Note: the VF drive associated with the supply fan is provided for balancing purposes only; the VF drive shall be set to a constant speed by the balancing subcontractor.
  - 1. The unit shall be provided with an airflow station mounted in the outdoor airstream to measure the exact amount of outdoor air the unit introduces into the system. The HVAC Trade shall determine whether the ATC subcontractor or the CAV RTU manufacturer shall provide the airflow station.
- C. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.
  - 1. A programmable controller shall be provided by the ATC subcontractor to control those actions described herein.
  - 2. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.
  - 3. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
  - 4. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and electric heat as applicable.
  - 5. Sensors:
    - a. Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.
    - b. Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.
- D. The DDC system shall determine through the start/stop optimization program and the time schedule program when to energize the CAV RTU for the warm-up mode prior to the area being occupied. The start/stop optimization program and time schedule program shall also determine when to de-energize the CAV RTU.
- E. When the CAV RTU is indexed to the Occupied operating mode, the DDC system shall control it according to the following sequence:
  - 1. Supply Fan: The supply fan shall be energized and shall run continuously.
  - 2. Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]: When the CAV RTU is initially energized, the normally closed outdoor air damper shall remain in its full closed position and the normally open return air damper shall remain in its full-open position for a period of 60 seconds. After 60 seconds has elapsed, the outdoor air damper and return air damper shall be controlled as follows:
    - a. Normal Mode: The outdoor air damper shall be opened to allow in the scheduled total supply airflow rate as determined by an airflow station mounted in the unit's outdoor airstream.



- 1) The exhaust fan shall be energized and its associated motorized damper shall be open. The exhaust fan's VF drive shall then be modulated to maintain the scheduled exhaust airflow rate.
3. Heat Recovery Device: In the normal mode, the heat recovery wheel shall operate. In the economizer mode, the heat recovery wheel shall be de-energized.
  - a. Frost Control:
    - 1) A temperature sensor shall be mounted in the exhaust airstream downstream of the heat recovery wheel and a dew point temperature sensor shall be mounted in the exhaust airstream upstream of the heat recovery wheel. The DDC system shall modulate a bypass air damper in order to bypass outdoor air around the heat recovery wheel to maintain exhaust airstream temperature downstream of the heat recovery wheel above the exhaust airstream dew point temperature.
4. Cooling Mode:
  - a. The DDC system shall first determine whether free cooling is available. If free cooling is available, then the unit's outdoor air damper, return air damper, and exhaust fan and associated motorized damper and shall be controlled as previously described in the subparagraph entitled "Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]" in this article.
  - b. If free cooling is not available, the DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature cooling setpoint of 75°F [adjustable]. If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
  - c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
5. Heating Mode:
  - a. The DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature heating setpoint of 70°F (adjustable). If the unit is operating in the heating mode, the associated condensing unit shall be energized.
  - b. Compressor and Refrigerant Reversing Valve: The water source heat pump unit's compressor shall be energized and de-energized and the position of its refrigerant reversing valve shall be controlled via the room's temperature sensor to maintain space cooling and heating setpoints.
  - c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
  - d. If all compressor stages are on and the space air temperature drops below the heating setpoint of 70°F, modulate the gas fired heating coil via to maintain a supply air temperature heating setpoint of 70°F [adjustable]. As the space temperature rises above the heating setpoint the electric heating coil shall be de-energized. If the unit is operating in the cooling mode, the electric heating coil shall be de-energized.
6. Dehumidification: Provide supply air humidity sensor[s] and space temperature sensor[s] for the system. Refer to the drawings for the location of the space humidity sensor[s] and the space temperature sensor[s]. The DDC system shall calculate actual supply air dew point temperature based upon actual supply air temperature and actual supply air humidity. When the highest space

dew point temperature rises above a setpoint of 55°F [adjustable], the unit shall be placed in its dehumidification mode. When placed in its dehumidification mode, the following shall occur:

- a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the unit's compressors on sequentially.
- b. The unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a space air temperature signal provided by the ATC Subcontractor.
- c. As the highest space dew point temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
- d. When the highest space dew point temperature drops below 54°F [adjustable], the unit shall be returned to its normal control mode.
- e. Provide the following points on the graphical display.
  - 1) AV [analog value] - Dew point temperature for each room with temperature and humidity sensors.
  - 2) AV - Lowest dew point temperature for the system.
  - 3) AV - Highest dew point for the system.
  - 4) AV - Dew point set point.

F. When the CAV RTU is indexed to the Unoccupied mode, the DDC system shall control it according to the following sequence:

1. The supply fan[s] shall be de-energized.
2. The outside air damper shall be closed and its return air damper shall be open.
3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
4. The heat recovery wheel shall be de-energized.
5. The air-cooled condensing section shall be de-energized.
6. The electric heating coil shall be de-energized.

G. Smoke Control: A duct mounted smoke detector, located in the supply and return air duct, shall stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the gas fired heating section when products of combustion are detected in the exhaust airstream.

H. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when discharge air temperature drops below 45°F [adjustable].

I. Provide a water level sensor mounted in the unit's drain pan to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when the water in the pan rises to within ½-inch [adjustable] of the top of the drain pan.

J. DDC Input/Output Points for CAV Rooftop Units:

1. AI Mixed Air Temperature
2. AI Discharge Air Temperature [at unit outlet]
3. AI Space Air Temperature
4. AI Space/Return Air Humidity

5. AI Outdoor Air Temperature
6. AI Outdoor Air Humidity
7. AI Discharge Temperature Setpoint Adjust
8. AI Outside Airflow Rate
9. AI Exhaust Fan Variable Frequency Drive Status
10. DI Supply Fan Status
11. DI Exhaust Fan Status
12. DI Manual Over-ride
13. DI Low Discharge Air Temperature Alarm
14. DI Smoke Detector Alarm
15. DI Drain Pan Water Level
16. DI Heat Recovery Wheel Status
17. DI Compressor Status [each stage]
18. DI Filter Pressure Differential
19. AO Outdoor Air Damper Position
20. AO Return Air Damper Position
21. AO Gas Fired Heating Coil
22. AO Exhaust Fan Variable Frequency Drive Speed
23. AO Heat Recovery Wheel Speed
24. DO Compressor On/Off [each compressor]
25. DO Heat Recovery Wheel On/Off
26. DO Relief Air Damper Open/Close
27. DO Supply Fan Start/Stop
28. DO Reversing Valve
29. DO Condenser Water Valve

- K. Coordinate the control system requirements described in this Section with the requirements described in Division 23 Section 23 7413 "Packaged Rooftop Air Conditioning Units."

### 3.7 ROOFTOP UNIT RTU-1

- A. The variable air volume [VAV] rooftop unit [RTU] shall be controlled via DDC type controls to accomplish the sequence described in this article.
- B. The VAV RTU consists of an outside-air damper, a return air damper, an electric pre-heat coil, heat pump compressor with refrigerant based heating and cooling coil, a refrigerant hot gas reheat coil, an electric reheat coil, a supply fan with variable frequency [VF] drive, an exhaust fan with VF drive. ALL actuators shall be electronic.
  1. The unit shall be provided with an airflow station mounted in the outdoor airstream to measure the exact amount of outdoor air the unit introduces into the system. The HVAC Trade shall determine whether the ATC subcontractor or the VAV RTU manufacturer shall provide the airflow station.
- C. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.
  1. A programmable controller shall be provided by the ATC subcontractor to control those actions described herein.
  2. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.

3. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
  4. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and electric heat as applicable.
  5. Sensors:
    - a. Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.
    - b. Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.
- D. The DDC system shall determine through the start/stop optimization program and the time schedule program when to energize the VAV RTU for the warm-up mode prior to the area being occupied. The start/stop optimization program and time schedule program shall also determine when to de-energize the VAV RTU.
- E. When the VAV RTU is indexed to the warm-up or cool-down mode, the DDC system shall control it according to the following sequence:
1. During the warm-up mode:
    - a. The supply fan[s] shall be energized and shall run continuously while in the morning warm-up mode.
    - b. The outside air damper shall be closed and the return air damper shall be open.
    - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
    - d. The electric pre-heat coil shall be energized at full capacity, then be staged on and off or modulated to maintain a minimum entering air temperature to the condenser coil of 40 deg. F.
    - e. The heat pump condenser water valve shall be opened.
    - f. The heat pump condensing section shall be energized.
    - g. The electric reheat coil shall be energized at full capacity and then shall be staged on and off or modulated to maintain space temperature at a setpoint of 72°F [adjustable].
  2. During the cool-down mode:
    - a. The supply fan[s] shall be energized and shall run continuously while in the morning cool down mode.
    - b. The outside air damper shall be closed and its return air damper shall be open.
    - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
    - d. The electric pre-heat coil shall be de-energized.
    - e. The heat pump condenser water valve shall be open.
    - f. The heat pump condensing section shall be energized at full capacity and then its compressors shall be staged on and off to avoid overshoot and to maintain a space air temperature setpoint of 75°F [adjustable].
    - g. The electric heating coil shall be de-energized.

- F. When the VAV RTU is indexed to the Occupied operating mode, the DDC system shall control it according to the following sequence:
1. Supply Fan: Supply Fan: The supply fan shall be energized and shall initially run to deliver 50% (adjustable) of the maximum scheduled supply airflow rate as determined by an airflow station mounted in the unit's supply air discharge airstream.
  2. Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]: When the VAV RTU is initially energized, the normally closed outdoor air damper shall remain in its full closed position and the normally open return air damper shall remain in its full-open position for a period of 60 seconds. After 60 seconds has elapsed, the outdoor air damper and return air damper shall be controlled as follows:
    - a. Normal Mode: The outdoor air damper shall initially be placed in its low occupancy minimum outdoor air position of 5% of the unit's scheduled total supply airflow rate as determined by an airflow station mounted in the unit's outdoor airstream. The DDC system shall then control the position of the outdoor air damper via the various space CO<sub>2</sub> sensors located in high occupancy spaces served by the system according to the "Ventilation Optimization" article in this Section. The high occupancy minimum outdoor air damper position shall be as indicated in the schedule on the Drawings.
    - b. Economizer Mode: When free cooling is available and space temperature is above setpoint, the outside air damper and the return air damper shall be modulated to maintain space air temperature setpoint. The DDC system shall compare the enthalpy of the outside air to the enthalpy of the return/exhaust air to determine whether free cooling is available.
      - 1) The exhaust fan shall be energized and its associated motorized damper shall be open. The exhaust fan's VF drive shall then be modulated to maintain a differential pressure of 0.03-inches w.g. [adjustable] measured between the space and the outdoors.
      - 2) The unit shall disengage the economizer cycle and revert to the normal mode whenever feedback from the CO<sub>2</sub> sensor demands more outside air than required to maintain the unit's discharge air temperature setpoint.
      - 3) Free cooling is available whenever the outdoor air enthalpy is less than 27.4 Btu/lb and the outside air temperature is less than the return air temperature.
  3. Cooling Mode:
    - a. The DDC system shall first determine whether free cooling is available. If free cooling is available, then the unit's outdoor air damper, return air damper, and exhaust fan and associated motorized damper and shall be controlled as previously described in the subparagraph entitled "Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]" in this article.
    - b. If free cooling is not available, the DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature cooling setpoint of 75°F [adjustable]. If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
    - c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
    - d. If the space temperature rises 2 degrees above setpoint, the fan speed shall increase 5% every 60 seconds (adjustable) until the fan speed causes the fan to deliver its maximum scheduled supply airflow rate or the space temperature is within 2 degrees of setpoint. If the space temperature falls 2-degrees below setpoint the fan speed shall be decreased in 5% increments every 60-seconds until the fan speed causes the fan to deliver its minimum scheduled supply airflow rate (adjustable). If the fan speed is running at its minimum setting

and the space temperature continues to drop, then the discharge air temperature shall be reset upwards by 0.10°F every 30 seconds (adjustable) until the discharge air temperature reaches 55 °F (adjustable).

4. Heating Mode:

- a. The electric pre-heat coil shall be energized and modulated to maintain a minimum entering air temperature of 40°F at the condenser coil.
- b. The DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature heating setpoint of 70°F (adjustable). If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
- c. Compressor and Refrigerant Reversing Valve: The water source heat pump unit's compressor shall be energized and de-energized and the position of its refrigerant reversing valve shall be controlled via the room's temperature sensor to maintain space cooling and heating setpoints.
- d. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
- e. If all compressor stages are on and the space air temperature drops below the heating setpoint of 70°F. If the space temperature drops 2 degrees below setpoint, the fan speed shall increase 5% every 60 seconds (adjustable) until the fan speed causes the fan to deliver its maximum scheduled supply airflow rate or the space temperature has reached setpoint. If the supply fan is delivering its maximum scheduled supply airflow rate, and the space has not reached the design setpoint, modulate the electric reheat coil via the coil's SCR controls to maintain a space air temperature heating setpoint of 70°F [adjustable]. If the space temperature rises 2-degrees above the heating setpoint, modulate the electric reheat coil's SCR controls to provide less heat. If the electric reheat coil is at its minimum output and the space temperature is still 2 degrees above the design setpoint, decrease the fan speed in 5% increments every 60-seconds until the fan speed causes the fan to deliver 50% of its scheduled supply airflow rate (adjustable). If the space temperature continues to rise, the heat pump compressors shall be staged off. If the unit is operating in the cooling mode, the electric heating coils shall be de-energized.

5. Dehumidification: Provide space humidity sensor[s] and space temperature sensor[s] for the system. Refer to the drawings for the location of the space humidity sensor[s] and the space temperature sensor[s]. The DDC system shall calculate actual space dew point temperature based upon actual space temperature and actual space humidity. When the highest space dew point temperature rises above a setpoint of 55°F [adjustable], the unit shall be placed in its dehumidification mode. When placed in its dehumidification mode, the following shall occur:

- a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the unit's compressors on sequentially.
- b. The unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a space air temperature signal provided by the ATC Subcontractor.
- c. As the highest space dew point temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
- d. When the highest space dew point temperature drops below 54°F [adjustable], the unit shall be returned to its normal control mode.

- e. Provide the following points on the graphical display.
  - 1) AV [analog value] - Dew point temperature for each room with temperature and humidity sensors.
  - 2) AV - Lowest dew point temperature for the system.
  - 3) AV - Highest dew point for the system.
  - 4) AV - Dew point set point.
- G. When the VAV RTU is indexed to the Unoccupied mode, the DDC system shall control it according to the following sequence:
  - 1. The supply fan[s] shall be de-energized.
  - 2. The outside air damper shall be closed and its return air damper shall be open.
  - 3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - 4. The electric pre-heat coil shall be de-energized.
  - 5. The heat pump condensing section shall be de-energized.
  - 6. The electric reheat coil shall be de-energized.
  - 7. Dehumidification: When space dew point temperature rises above a setpoint of 55°F [adjustable], the unit supply fan shall be energized, the unit's compressors shall be energized sequentially in order to modulate the cooling coil leaving air temperature towards 50°F, and the unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit's exhaust fan shall remain de-energized, the unit's heat recovery wheel shall remain de-energized, the return air damper shall remain open and the outdoor air damper shall remain closed. When space dew point temperature drops below 54°F [adjustable], the unit's supply and exhaust fans shall be de-energized, the unit's heat recovery wheel shall be de-energized, and the unit's compressors shall be de-energized. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a discharge air temperature signal provided by the ATC Subcontractor.
- H. Night Setback Mode: If space temperature drops below the night setback temperature setpoint of 60°F [adjustable] when the unit is in the Unoccupied Mode, the following shall occur:
  - 1. The supply fan[s] shall be energized.
  - 2. The outside air damper shall remain closed and its return air damper shall remain open.
  - 3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - 4. The heat pump condensing section shall be energized and shall operate at full capacity. When space temperature rises 2°F [adjustable] above the night setback temperature setpoint, the CAV RTU shall revert back to the unoccupied mode
  - 5. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
  - 6. The electric reheating coil shall be de-energized.
- I. Smoke Control: Duct mounted smoke detectors, located in the supply and duct and return air duct, shall stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device, de-energize the electric pre-heating coil, and de-energize the electric reheating coil when products of combustion are detected in the exhaust airstream.
- J. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when discharge air temperature drops below 45°F [adjustable].

K. Provide a water level sensor mounted in the unit's drain pan to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when the water in the pan rises to within ½-inch [adjustable] of the top of the drain pan.

L. DDC Input/Output Points for VAV Rooftop Units:

1. AI Mixed Air Temperature
2. AI Pre-heat Coil Leaving Air Temperature [where pre-heat coils are provided]
3. AI Discharge Air Temperature [at unit outlet]
4. AI Space Air Temperature
5. AI Space/Return Air Humidity
6. AI Outdoor Air Temperature
7. AI Outdoor Air Humidity
8. AI Space Differential Pressure
9. AI Discharge Temperature Setpoint Adjust
10. AI Space CO2 Level
11. AI Outside Airflow Rate
12. AI Exhaust Fan Variable Frequency Drive Status
13. DI Supply Fan Status
14. DI Exhaust Fan Status
15. DI Manual Over-ride
16. DI Low Discharge Air Temperature Alarm
17. DI Smoke Detector Alarm
18. DI Drain Pan Water Level
19. DI Heat Recovery Wheel Status
20. DI Compressor Status [each stage]
21. DI Filter Pressure Differential
22. AO Outdoor Air Damper Position
23. AO Return Air Damper Position
24. AO Electric Preheat Coil
25. AO Electric Reheat Coil
26. AO Exhaust Fan Variable Frequency Drive Speed
27. DO Compressor On/Off [each compressor]
28. DO Electric Preheat Coil On/Off
29. DO Electric Reheat Coil On/Off
30. DO Relief Air Damper Open/Close
31. DO Supply Fan Start/Stop
32. DO Reversing Valve
33. DO Condenser Water Valve

M. Coordinate the control system requirements described in this Section with the requirements described in Division 23 Section 23 7413 "Packaged Rooftop Air Conditioning Units."

### 3.8 ROOFTOP UNITS RTU-2 and 5

A. The variable air volume [VAV] rooftop unit [RTU] shall be controlled via DDC type controls to accomplish the sequence described in this article.



B. The VAV RTU consists of an outside-air damper, a return air damper, a heat recovery device, an electric pre-heat coil, heat pump compressor with refrigerant based heating and cooling coil, a refrigerant hot gas reheat coil, an electric reheat coil, a supply fan with variable frequency [VF] drive, an exhaust fan with VF drive. ALL actuators shall be electronic.

1. The unit shall be provided with an airflow station mounted in the outdoor airstream to measure the exact amount of outdoor air the unit introduces into the system. The HVAC Trade shall determine whether the ATC subcontractor or the VAV RTU manufacturer shall provide the airflow station.

C. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.

1. A programmable controller shall be provided by the ATC subcontractor to control those actions described herein.
2. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.
3. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
4. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and electric heat as applicable.
5. Sensors:
  - a. Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.
  - b. Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.

D. The DDC system shall determine through the start/stop optimization program and the time schedule program when to energize the VAV RTU for the warm-up mode prior to the area being occupied. The start/stop optimization program and time schedule program shall also determine when to de-energize the VAV RTU.

E. When the VAV RTU is indexed to the warm-up or cool-down mode, the DDC system shall control it according to the following sequence:

1. During the warm-up mode:
  - a. The supply fan[s] shall be energized and shall run continuously while in the morning warm-up mode.
  - b. The outside air damper shall be closed and the return air damper shall be open.
  - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - d. The heat recovery wheel shall be de-energized.
  - e. The electric pre-heat coil shall be energized at full capacity, then be staged on and off or modulated to maintain a minimum entering air temperature to the condenser coil of 40°F.
  - f. The heat pump condenser water valve shall be opened.
  - g. The heat pump condensing section shall be energized.
  - h. The electric reheat coil shall be energized at full capacity and then shall be staged on and off or modulated to maintain space temperature at a setpoint of 72°F [adjustable].

2. During the cool-down mode:

- a. The supply fan[s] shall be energized and shall run continuously while in the morning cool down mode.
- b. The outside air damper shall be closed and its return air damper shall be open.
- c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
- d. The heat recovery wheel shall be de-energized.
- e. The electric pre-heat coil shall be de-energized.
- f. The heat pump condenser water valve shall be open.
- g. The heat pump condensing section shall be energized at full capacity and then its compressors shall be staged on and off to avoid overshoot and to maintain a space air temperature setpoint of 75°F [adjustable].
- h. The electric heating coil shall be de-energized.

F. When the VAV RTU is indexed to the Occupied operating mode, the DDC system shall control it according to the following sequence:

1. Supply Fan: Supply Fan: The supply fan shall be energized and shall initially run to deliver 50% (adjustable) of the maximum scheduled supply airflow rate as determined by an airflow station mounted in the unit's supply air discharge airstream.
2. Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]: When the VAV RTU is initially energized, the normally closed outdoor air damper shall remain in its full closed position and the normally open return air damper shall remain in its full-open position for a period of 60 seconds. After 60 seconds has elapsed, the outdoor air damper and return air damper shall be controlled as follows:
  - a. Normal Mode: The outdoor air damper shall initially be placed in its low occupancy minimum outdoor air position of 5% of the unit's scheduled total supply airflow rate as determined by an airflow station mounted in the unit's outdoor airstream. The DDC system shall then control the position of the outdoor air damper via the various space CO<sub>2</sub> sensors located in high occupancy spaces served by the system according to the "Ventilation Optimization" article in this Section. The high occupancy minimum outdoor air damper position shall be as indicated in the schedule on the Drawings.
  - b. Economizer Mode: When free cooling is available and space temperature is above setpoint, the outside air damper and the return air damper shall be modulated to maintain space air temperature setpoint. The DDC system shall compare the enthalpy of the outside air to the enthalpy of the return/exhaust air to determine whether free cooling is available.
    - 1) The exhaust fan shall be energized and its associated motorized damper shall be open. The exhaust fan's VF drive shall then be modulated to maintain a differential pressure of 0.03-inches w.g. [adjustable] measured between the space and the outdoors.
    - 2) The unit shall disengage the economizer cycle and revert to the normal mode whenever feedback from the CO<sub>2</sub> sensor demands more outside air than required to maintain the unit's discharge air temperature setpoint.
    - 3) Free cooling is available whenever the outdoor air enthalpy is less than 27.4 Btu/lb and the outside air temperature is less than the return air temperature.

3. Heat Recovery Device: In the normal mode, the heat recovery wheel shall operate. In the economizer mode, the heat recovery wheel shall be de-energized.

a. Frost Control:

- 1) A temperature sensor shall be mounted in the exhaust airstream downstream of the heat recovery wheel and a dew point temperature sensor shall be mounted in the exhaust airstream upstream of the heat recovery wheel. The DDC system shall modulate a bypass air damper in order to bypass outdoor air around the heat recovery wheel to maintain exhaust airstream temperature downstream of the heat recovery wheel above the exhaust airstream dew point temperature.

4. Cooling Mode:

- a. The DDC system shall first determine whether free cooling is available. If free cooling is available, then the unit's outdoor air damper, return air damper, and exhaust fan and associated motorized damper and shall be controlled as previously described in the subparagraph entitled "Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]" in this article.
- b. If free cooling is not available, the DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature cooling setpoint of 75°F [adjustable]. If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
- c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
- d. If the space temperature rises 2 degrees above setpoint, the fan speed shall increase 5% every 60 seconds (adjustable) until the fan speed causes the fan to deliver its maximum scheduled supply airflow rate or the space temperature is within 2 degrees of setpoint. If the space temperature falls 2-degrees below setpoint the fan speed shall be decreased in 5% increments every 60-seconds until the fan speed causes the fan to deliver its minimum scheduled supply airflow rate (adjustable). If the fan speed is running at its minimum setting and the space temperature continues to drop, then the discharge air temperature shall be reset upwards by 0.10°F every 30 seconds (adjustable) until the discharge air temperature reaches 55°F (adjustable).

5. Heating Mode:

- a. The electric pre-heat coil shall be energized and modulated to maintain a minimum entering air temperature of 40 deg. F at the condenser coil.
- b. The DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature heating setpoint of 70°F (adjustable). If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
- c. Compressor and Refrigerant Reversing Valve: The water source heat pump unit's compressor shall be energized and de-energized and the position of its refrigerant reversing valve shall be controlled via the room's temperature sensor to maintain space cooling and heating setpoints.
- d. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.

- e. If all compressor stages are on and the space air temperature drops below the heating setpoint of 70°F. If the space temperature drops 2 degrees below setpoint, the fan speed shall increase 5% every 60 seconds (adjustable) until the fan speed causes the fan to deliver its maximum scheduled supply airflow rate or the space temperature has reached setpoint. If the supply fan is delivering its maximum scheduled supply airflow rate, and the space has not reached the design setpoint, modulate the electric reheat coil via the coil's SCR controls to maintain a space air temperature heating setpoint of 70°F [adjustable]. If the space temperature rises 2-degrees above the heating setpoint, modulate the electric reheat coil's SCR controls to provide less heat. If the electric reheat coil is at its minimum output and the space temperature is still 2 degrees above the design setpoint, decrease the fan speed in 5% increments every 60-seconds until the fan speed causes the fan to deliver 50% of its scheduled supply airflow rate (adjustable). If the space temperature continues to rise, the heat pump compressors shall be staged off. If the unit is operating in the cooling mode, the electric heating coils shall be de-energized.
6. Dehumidification: Provide space humidity sensor[s] and space temperature sensor[s] for the system. Refer to the drawings for the location of the space humidity sensor[s] and the space temperature sensor[s]. The DDC system shall calculate actual space dew point temperature based upon actual space temperature and actual space humidity. When the highest space dew point temperature rises above a setpoint of 55°F [adjustable], the unit shall be placed in its dehumidification mode. When placed in its dehumidification mode, the following shall occur:
- a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the unit's compressors on sequentially.
  - b. The unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a space air temperature signal provided by the ATC Subcontractor.
  - c. As the highest space dew point temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
  - d. When the highest space dew point temperature drops below 54°F [adjustable], the unit shall be returned to its normal control mode.
  - e. Provide the following points on the graphical display.
    - 1) AV [analog value] - Dew point temperature for each room with temperature and humidity sensors.
    - 2) AV - Lowest dew point temperature for the system.
    - 3) AV - Highest dew point for the system.
    - 4) AV - Dew point set point.
- G. When the VAV RTU is indexed to the Unoccupied mode, the DDC system shall control it according to the following sequence:
- 1. The supply fan[s] shall be de-energized.
  - 2. The outside air damper shall be closed and its return air damper shall be open.
  - 3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - 4. The heat recovery wheel shall be de-energized.
  - 5. The electric pre-heat coil shall be de-energized.
  - 6. The heat pump condensing section shall be de-energized.
  - 7. The electric reheat coil shall be de-energized.

8. Dehumidification: When space dew point temperature rises above a setpoint of 55°F [adjustable], the unit supply fan shall be energized, the unit's compressors shall be energized sequentially in order to modulate the cooling coil leaving air temperature towards 50°F, and the unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit's exhaust fan shall remain de-energized, the unit's heat recovery wheel shall remain de-energized, the return air damper shall remain open and the outdoor air damper shall remain closed. When space dew point temperature drops below 54°F [adjustable], the unit's supply and exhaust fans shall be de-energized, the unit's heat recovery wheel shall be de-energized, and the unit's compressors shall be de-energized. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a discharge air temperature signal provided by the ATC Subcontractor.
- H. Night Setback Mode: If space temperature drops below the night setback temperature setpoint of 60°F [adjustable] when the unit is in the Unoccupied Mode, the following shall occur:
1. The supply fan[s] shall be energized.
  2. The outside air damper shall remain closed and its return air damper shall remain open.
  3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  4. The heat recovery wheel shall be de-energized.
  5. The heat pump condensing section shall be energized and shall operate at full capacity. When space temperature rises 2°F [adjustable] above the night setback temperature setpoint, the CAV RTU shall revert back to the unoccupied mode
  6. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
  7. The electric reheating coil shall be de-energized.
- I. Smoke Control: Duct mounted smoke detectors, located in the supply and duct and return air duct, shall stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device, de-energize the electric pre-heating coil, and de-energize the electric reheating coil when products of combustion are detected in the exhaust airstream.
- J. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when discharge air temperature drops below 45°F [adjustable].
- K. Provide a water level sensor mounted in the unit's drain pan to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when the water in the pan rises to within ½-inch [adjustable] of the top of the drain pan.
- L. DDC Input/Output Points for VAV Rooftop Units:
1. AI Mixed Air Temperature
  2. AI Pre-heat Coil Leaving Air Temperature [where pre-heat coils are provided]
  3. AI Discharge Air Temperature [at unit outlet]
  4. AI Space Air Temperature
  5. AI Space/Return Air Humidity
  6. AI Outdoor Air Temperature
  7. AI Outdoor Air Humidity
  8. AI Space Differential Pressure
  9. AI Discharge Temperature Setpoint Adjust
  10. AI Space CO2 Level

11. AI Outside Airflow Rate
12. AI Exhaust Fan Variable Frequency Drive Status
13. DI Supply Fan Status
14. DI Exhaust Fan Status
15. DI Manual Over-ride
16. DI Low Discharge Air Temperature Alarm
17. DI Smoke Detector Alarm
18. DI Drain Pan Water Level
19. DI Heat Recovery Wheel Status
20. DI Compressor Status [each stage]
21. DI Filter Pressure Differential
22. AO Outdoor Air Damper Position
23. AO Return Air Damper Position
24. AO Electric Preheat Coil
25. AO Electric Reheat Coil
26. AO Exhaust Fan Variable Frequency Drive Speed
27. AO Heat Recovery Wheel Speed
28. DO Compressor On/Off [each compressor]
29. DO Heat Recovery Wheel On/Off
30. DO Electric Preheat Coil On/Off
31. DO Electric Reheat Coil On/Off
32. DO Relief Air Damper Open/Close
33. DO Supply Fan Start/Stop
34. DO Reversing Valve
35. DO Condenser Water Valve

- M. Coordinate the control system requirements described in this Section with the requirements described in Division 23 Section 23 7413 "Packaged Rooftop Air Conditioning Units."

### 3.9 ROOFTOP UNITS RTU-3 and 4

- A. The variable air volume [VAV] rooftop unit [RTU] shall be controlled via DDC type controls to accomplish the sequence described in this article.
- B. The VAV RTU consists of an outside-air damper, a return air damper, a heat recovery device, a, heat pump compressor with refrigerant based heating and cooling coil, a refrigerant hot gas reheat coil, a supply fan with variable frequency [VF] drive, an exhaust fan with VF drive. ALL actuators shall be electronic.
  1. The unit shall be provided with an airflow station mounted in the outdoor airstream to measure the exact amount of outdoor air the unit introduces into the system. The HVAC Trade shall determine whether the ATC subcontractor or the VAV RTU manufacturer shall provide the airflow station.
- C. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.
  1. A programmable controller shall be provided by the ATC subcontractor to control those actions described herein.
  2. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.

3. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
  4. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and electric heat as applicable.
  5. Sensors:
    - a. Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.
    - b. Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.
- D. The DDC system shall determine through the start/stop optimization program and the time schedule program when to energize the VAV RTU for the warm-up mode prior to the area being occupied. The start/stop optimization program and time schedule program shall also determine when to de-energize the VAV RTU.
- E. When the VAV RTU is indexed to the warm-up or cool-down mode, the DDC system shall control it according to the following sequence:
1. During the warm-up mode:
    - a. The supply fan[s] shall be energized and shall run continuously while in the morning warm-up mode.
    - b. The outside air damper shall be closed and the return air damper shall be open.
    - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
    - d. The heat recovery wheel shall be de-energized.
    - e. The heat pump condenser water valve shall be opened.
    - f. The heat pump condensing section shall be energized.
  2. During the cool-down mode:
    - a. The supply fan[s] shall be energized and shall run continuously while in the morning cool down mode.
    - b. The outside air damper shall be closed and its return air damper shall be open.
    - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
    - d. The heat recovery wheel shall be de-energized.
    - e. The heat pump condenser water valve shall be open.
    - f. The heat pump condensing section shall be energized at full capacity and then its compressors shall be staged on and off to avoid overshoot and to maintain a space air temperature setpoint of 75°F [adjustable].
- F. When the VAV RTU is indexed to the Occupied operating mode, the DDC system shall control it according to the following sequence:
1. Supply Fan: Supply Fan: The supply fan shall be energized and shall initially run to deliver 50% (adjustable) of the maximum scheduled supply airflow rate as determined by an airflow station mounted in the unit's supply air discharge airstream.

2. Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]: When the VAV RTU is initially energized, the normally closed outdoor air damper shall remain in its full closed position and the normally open return air damper shall remain in its full-open position for a period of 60 seconds. After 60 seconds has elapsed, the outdoor air damper and return air damper shall be controlled as follows:
  - a. Normal Mode: The outdoor air damper shall initially be placed in its low occupancy minimum outdoor air position of 5% of the unit's scheduled total supply airflow rate as determined by an airflow station mounted in the unit's outdoor airstream. The DDC system shall then control the position of the outdoor air damper via the various space CO<sub>2</sub> sensors located in high occupancy spaces served by the system according to the "Ventilation Optimization" article in this Section. The high occupancy minimum outdoor air damper position shall be as indicated in the schedule on the Drawings.
  - b. Economizer Mode: When free cooling is available and space temperature is above setpoint, the outside air damper and the return air damper shall be modulated to maintain space air temperature setpoint. The DDC system shall compare the enthalpy of the outside air to the enthalpy of the return/exhaust air to determine whether free cooling is available.
    - 1) The exhaust fan shall be energized and its associated motorized damper shall be open. The exhaust fan's VF drive shall then be modulated to maintain a differential pressure of 0.03-inches w.g. [adjustable] measured between the space and the outdoors.
    - 2) The unit shall disengage the economizer cycle and revert to the normal mode whenever feedback from the CO<sub>2</sub> sensor demands more outside air than required to maintain the unit's discharge air temperature setpoint.
    - 3) Free cooling is available whenever the outdoor air enthalpy is less than 27.4 Btu/lb and the outside air temperature is less than the return air temperature.
3. Heat Recovery Device: In the normal mode, the heat recovery wheel shall operate. In the economizer mode, the heat recovery wheel shall be de-energized.
  - a. Frost Control:
    - 1) A temperature sensor shall be mounted in the exhaust airstream downstream of the heat recovery wheel and a dew point temperature sensor shall be mounted in the exhaust airstream upstream of the heat recovery wheel. The DDC system shall modulate a bypass air damper in order to bypass outdoor air around the heat recovery wheel to maintain exhaust airstream temperature downstream of the heat recovery wheel above the exhaust airstream dew point temperature.
4. Cooling Mode:
  - a. The DDC system shall first determine whether free cooling is available. If free cooling is available, then the unit's outdoor air damper, return air damper, and exhaust fan and associated motorized damper and shall be controlled as previously described in the subparagraph entitled "Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]" in this article.
  - b. If free cooling is not available, the DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature cooling setpoint of 75°F [adjustable]. If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.



- c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
  - d. If the space temperature rises 2 degrees above setpoint, the fan speed shall increase 5% every 60 seconds (adjustable) until the fan speed causes the fan to deliver its maximum scheduled supply airflow rate or the space temperature is within 2 degrees of setpoint. If the space temperature falls 2-degrees below setpoint the fan speed shall be decreased in 5% increments every 60-seconds until the fan speed causes the fan to deliver its minimum scheduled supply airflow rate (adjustable). If the fan speed is running at its minimum setting and the space temperature continues to drop, then the discharge air temperature shall be reset upwards by 0.10°F every 30 seconds (adjustable) until the discharge air temperature reaches 55°F (adjustable).
5. Heating Mode:
- a. The DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature heating setpoint of 70°F (adjustable). If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
  - b. Compressor and Refrigerant Reversing Valve: The water source heat pump unit's compressor shall be energized and de-energized and the position of its refrigerant reversing valve shall be controlled via the room's temperature sensor to maintain space cooling and heating setpoints.
  - c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
  - d. If all compressor stages are on and the space air temperature drops below the heating setpoint of 70°F. If the space temperature drops 2 degrees below setpoint, the fan speed shall increase 5% every 60 seconds (adjustable) until the fan speed causes the fan to deliver its maximum scheduled supply airflow rate or the space temperature has reached setpoint. If the space temperature rises 2-degrees above the heating setpoint, decrease the fan speed in 5% increments every 60-seconds until the fan speed causes the fan to deliver 50% of its scheduled supply airflow rate (adjustable). If the space temperature continues to rise, the heat pump compressors shall be staged off.
6. Dehumidification: Provide space humidity sensor[s] and space temperature sensor[s] for the system. Refer to the drawings for the location of the space humidity sensor[s] and the space temperature sensor[s]. The DDC system shall calculate actual space dew point temperature based upon actual space temperature and actual space humidity. When the highest space dew point temperature rises above a setpoint of 55°F [adjustable], the unit shall be placed in its dehumidification mode. When placed in its dehumidification mode, the following shall occur:
- a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the unit's compressors on sequentially.
  - b. The unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a space air temperature signal provided by the ATC Subcontractor.
  - c. As the highest space dew point temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
  - d. When the highest space dew point temperature drops below 54°F [adjustable], the unit shall be returned to its normal control mode.

- e. Provide the following points on the graphical display.
  - 1) AV [analog value] - Dew point temperature for each room with temperature and humidity sensors.
  - 2) AV - Lowest dew point temperature for the system.
  - 3) AV - Highest dew point for the system.
  - 4) AV - Dew point set point.
- G. When the VAV RTU is indexed to the Unoccupied mode, the DDC system shall control it according to the following sequence:
  - 1. The supply fan[s] shall be de-energized.
  - 2. The outside air damper shall be closed and its return air damper shall be open.
  - 3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - 4. The heat recovery wheel shall be de-energized.
  - 5. The heat pump condensing section shall be de-energized.
  - 6. Dehumidification: When space dew point temperature rises above a setpoint of 55°F [adjustable], the unit supply fan shall be energized, the unit's compressors shall be energized sequentially in order to modulate the cooling coil leaving air temperature towards 50°F, and the unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit's exhaust fan shall remain de-energized, the unit's heat recovery wheel shall remain de-energized, the return air damper shall remain open and the outdoor air damper shall remain closed. When space dew point temperature drops below 54°F [adjustable], the unit's supply and exhaust fans shall be de-energized, the unit's heat recovery wheel shall be de-energized, and the unit's compressors shall be de-energized. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a discharge air temperature signal provided by the ATC Subcontractor.
- H. Night Setback Mode: If space temperature drops below the night setback temperature setpoint of 60°F [adjustable] when the unit is in the Unoccupied Mode, the following shall occur:
  - 1. The supply fan[s] shall be energized.
  - 2. The outside air damper shall remain closed and its return air damper shall remain open.
  - 3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - 4. The heat recovery wheel shall be de-energized.
  - 5. The heat pump condenser water valve shall be open.
  - 6. The heat pump condensing section shall be energized.
- I. Smoke Control: Duct mounted smoke detectors, located in the supply and duct and return air duct, shall stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device, de-energize the electric pre-heating coil, and de-energize the electric reheating coil when products of combustion are detected in the exhaust airstream.
- J. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when discharge air temperature drops below 45°F [adjustable].
- K. Provide a water level sensor mounted in the unit's drain pan to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when the water in the pan rises to within ½-inch [adjustable] of the top of the drain pan.

L. DDC Input/Output Points for VAV Rooftop Units:

1. AI Mixed Air Temperature
2. AI Pre-heat Coil Leaving Air Temperature [where pre-heat coils are provided]
3. AI Discharge Air Temperature [at unit outlet]
4. AI Space Air Temperature
5. AI Space/Return Air Humidity
6. AI Outdoor Air Temperature
7. AI Outdoor Air Humidity
8. AI Space Differential Pressure
9. AI Discharge Temperature Setpoint Adjust
10. AI Space CO2 Level
11. AI Outside Airflow Rate
12. AI Exhaust Fan Variable Frequency Drive Status
13. DI Supply Fan Status
14. DI Exhaust Fan Status
15. DI Manual Over-ride
16. DI Low Discharge Air Temperature Alarm
17. DI Smoke Detector Alarm
18. DI Drain Pan Water Level
19. DI Heat Recovery Wheel Status
20. DI Compressor Status [each stage]
21. DI Filter Pressure Differential
22. AO Outdoor Air Damper Position
23. AO Return Air Damper Position
24. AO Exhaust Fan Variable Frequency Drive Speed
25. AO Heat Recovery Wheel Speed
26. DO Compressor On/Off [each compressor]
27. DO Heat Recovery Wheel On/Off
28. DO Relief Air Damper Open/Close
29. DO Supply Fan Start/Stop
30. DO Reversing Valve
31. DO Condenser Water Valve

M. Coordinate the control system requirements described in this Section with the requirements described in Division 23 Section 23 7413 "Packaged Rooftop Air Conditioning Units."

**3.10 ROOFTOP UNITS RTU-6**

- A. The variable air volume [CAV] rooftop unit [RTU] shall be controlled via DDC type controls to accomplish the sequence described in this article.
- A. The CAV RTU consists of an outside-air damper, a return air damper, a heat recovery device, an electric pre-heat coil, heat pump compressor with refrigerant based heating and cooling coil, a refrigerant hot gas reheat coil, an electric reheat coil, a supply fan with variable frequency [VF] drive, an exhaust fan with VF drive. ALL actuators shall be electronic. Note: the VF drive associated with the supply fan is provided for balancing purposes only; the VF drive shall be set to a constant speed by the balancing subcontractor.
1. The unit shall be provided with an airflow station mounted in the outdoor airstream to measure the exact amount of outdoor air the unit introduces into the system. The HVAC Trade shall determine whether the ATC subcontractor or the CAV RTU manufacturer shall provide the airflow station.

B. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.

1. A programmable controller shall be provided by the ATC subcontractor to control those actions described herein.
2. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.
3. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
4. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and electric heat as applicable.
5. Sensors:
  - a. Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.
  - b. Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.

C. The DDC system shall determine through the start/stop optimization program and the time schedule program when to energize the CAV RTU for the warm-up mode prior to the area being occupied. The start/stop optimization program and time schedule program shall also determine when to de-energize the CAV RTU.

D. When the CAV RTU is indexed to the warm-up or cool-down mode, the DDC system shall control it according to the following sequence:

1. During the warm-up mode:
  - a. The supply fan[s] shall be energized and shall run continuously while in the morning warm-up mode.
  - b. The outside air damper shall be closed and the return air damper shall be open.
  - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  - d. The heat recovery wheel shall be de-energized.
  - e. The electric pre-heat coil shall be energized at full capacity, then be staged on and off or modulated to maintain a minimum entering air temperature to the condenser coil of 40°F.
  - f. The heat pump condenser water valve shall be opened.
  - g. The heat pump condensing section shall be energized.
  - h. The electric reheat coil shall be energized at full capacity and then shall be staged on and off or modulated to maintain space temperature at a setpoint of 72°F [adjustable].
2. During the cool-down mode:
  - a. The supply fan[s] shall be energized and shall run continuously while in the morning cool down mode.
  - b. The outside air damper shall be closed and its return air damper shall be open.
  - c. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.

- d. The heat recovery wheel shall be de-energized.
  - e. The electric pre-heat coil shall be de-energized.
  - f. The heat pump condenser water valve shall be open.
  - g. The heat pump condensing section shall be energized at full capacity and then its compressors shall be staged on and off to avoid overshoot and to maintain a space air temperature setpoint of 75°F [adjustable].
  - h. The electric heating coil shall be de-energized.
- E. When the CAV RTU is indexed to the Occupied operating mode, the DDC system shall control it according to the following sequence:
- 1. Supply Fan: The supply fan shall be energized and shall run continuously.
  - 2. Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]: When the CAV RTU is initially energized, the normally closed outdoor air damper shall remain in its full closed position and the normally open return air damper shall remain in its full-open position for a period of 60 seconds. After 60 seconds has elapsed, the outdoor air damper and return air damper shall be controlled as follows:
    - a. Normal Mode: The outdoor air damper shall be opened to allow in the scheduled total supply airflow rate as determined by an airflow station mounted in the unit's outdoor airstream.
      - 1) The exhaust fan shall be energized and its associated motorized damper shall be open. The exhaust fan's VF drive shall then be modulated to maintain the scheduled exhaust airflow rate.
  - 3. Heat Recovery Device: In the normal mode, the heat recovery wheel shall operate. In the economizer mode, the heat recovery wheel shall be de-energized.
    - a. Frost Control:
      - 1) A temperature sensor shall be mounted in the exhaust airstream downstream of the heat recovery wheel and a dew point temperature sensor shall be mounted in the exhaust airstream upstream of the heat recovery wheel. The DDC system shall modulate a bypass air damper in order to bypass outdoor air around the heat recovery wheel to maintain exhaust airstream temperature downstream of the heat recovery wheel above the exhaust airstream dew point temperature.
  - 4. Cooling Mode:
    - a. The DDC system shall first determine whether free cooling is available. If free cooling is available, then the unit's outdoor air damper, return air damper, and exhaust fan and associated motorized damper and shall be controlled as previously described in the subparagraph entitled "Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]" in this article.
    - b. If free cooling is not available, the DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature cooling setpoint of 75°F [adjustable]. If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
    - c. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.

5. Heating Mode:

- a. The electric pre-heat coil shall be energized and modulated to maintain a minimum entering air temperature of 40°F at the condenser coil.
- b. The DDC system shall stage the compressors of the condensing section on and off to maintain a space air temperature heating setpoint of 70°F (adjustable). If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
- c. Compressor and Refrigerant Reversing Valve: The water source heat pump unit's compressor shall be energized and de-energized and the position of its refrigerant reversing valve shall be controlled via the room's temperature sensor to maintain space cooling and heating setpoints.
- d. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.

6. Dehumidification: Provide supply air humidity sensor[s] and space temperature sensor[s] for the system. Refer to the drawings for the location of the space humidity sensor[s] and the space temperature sensor[s]. The DDC system shall calculate actual supply air dew point temperature based upon actual supply air temperature and actual supply air humidity. When the highest space dew point temperature rises above a setpoint of 55°F [adjustable], the unit shall be placed in its dehumidification mode. When placed in its dehumidification mode, the following shall occur:

- a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the unit's compressors on sequentially.
- b. The unit's hot gas reheat valve shall be modulated to maintain space air temperature at setpoint. The unit manufacturer's internal hot gas reheat controller shall modulate its hot gas reheat valve based on a space air temperature signal provided by the ATC Subcontractor.
- c. As the highest space dew point temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
- d. When the highest space dew point temperature drops below 54°F [adjustable], the unit shall be returned to its normal control mode.
- e. Provide the following points on the graphical display.
  - 1) AV [analog value] - Dew point temperature for each room with temperature and humidity sensors.
  - 2) AV - Lowest dew point temperature for the system.
  - 3) AV - Highest dew point for the system.
  - 4) AV - Dew point set point.

F. When the CAV RTU is indexed to the Unoccupied mode, the DDC system shall control it according to the following sequence:

1. The supply fan[s] shall be de-energized.
2. The outside air damper shall be closed and its return air damper shall be open.
3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
4. The heat recovery wheel shall be de-energized.
5. The air-cooled condensing section shall be de-energized.
6. The electric heating coils shall be de-energized.

- G. Night Setback Mode: If space temperature drops below the night setback temperature setpoint of 60°F [adjustable] when the unit is in the Unoccupied Mode, the following shall occur:
1. The supply fan[s] shall be energized.
  2. The outside air damper shall remain closed and its return air damper shall remain open.
  3. The exhaust fan shall be de-energized and its associated motorized damper shall be closed.
  4. The heat recovery wheel shall be de-energized.
  5. The heat pump condensing section shall be energized and shall operate at full capacity. When space temperature rises 2°F [adjustable] above the night setback temperature setpoint, the CAV RTU shall revert back to the unoccupied mode
  6. Condenser Water Valve: Unit shall be furnished with a 2-way, 2-position, normally closed condenser water valve. The valve shall be open whenever the compressor is operating and shall be closed whenever the compressor is off.
  7. The electric reheating coil shall be de-energized.
- H. Smoke Control: Duct mounted smoke detectors, located in the supply and duct and return air duct, shall stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device, de-energize the electric pre-heating coil, and de-energize the electric reheating coil when products of combustion are detected in the exhaust airstream.
- I. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when discharge air temperature drops below 45°F [adjustable].
- J. Provide a water level sensor mounted in the unit's drain pan to stop the supply fan, close the outside air damper, open the return air damper, de-energize the condensing section, de-energize the heat recovery device and de-energize the electric heating coil when the water in the pan rises to within ½-inch [adjustable] of the top of the drain pan.
- K. DDC Input/Output Points for CAV Rooftop Units:
1. AI Mixed Air Temperature
  2. AI Pre-heat Coil Leaving Air Temperature [where pre-heat coils are provided]
  3. AI Discharge Air Temperature [at unit outlet]
  4. AI Space Air Temperature
  5. AI Space/Return Air Humidity
  6. AI Outdoor Air Temperature
  7. AI Outdoor Air Humidity
  8. AI Space Differential Pressure
  9. AI Discharge Temperature Setpoint Adjust
  10. AI Space CO2 Level
  11. AI Outside Airflow Rate
  12. AI Exhaust Fan Variable Frequency Drive Status
  13. DI Supply Fan Status
  14. DI Exhaust Fan Status
  15. DI Manual Over-ride
  16. DI Low Discharge Air Temperature Alarm
  17. DI Smoke Detector Alarm
  18. DI Drain Pan Water Level
  19. DI Heat Recovery Wheel Status
  20. DI Compressor Status [each stage]

21. DI Filter Pressure Differential
22. AO Outdoor Air Damper Position
23. AO Return Air Damper Position
24. AO Electric Preheat Coil
25. AO Electric Reheat Coil
26. AO Exhaust Fan Variable Frequency Drive Speed
27. AO Heat Recovery Wheel Speed
28. DO Compressor On/Off [each compressor]
29. DO Heat Recovery Wheel On/Off
30. DO Electric Preheat Coil On/Off
31. DO Electric Reheat Coil On/Off
32. DO Relief Air Damper Open/Close
33. DO Supply Fan Start/Stop
34. DO Reversing Valve
35. DO Condenser Water Valve

- L. Coordinate the control system requirements described in this Section with the requirements described in Division 23 Section 23 7413 "Packaged Rooftop Air Conditioning Units."

### 3.11 MISCELLANEOUS COMMON POINTS

- A. The ATC Subcontractor shall provide the following sensors that shall be common to all sequences:
  1. A minimum of two [2] outdoor air temperature sensors shall be provided. These sensors shall be mounted on the north facing side of the building and shall be provided with sun shields [if necessary]. The temperature measurements from the two sensors shall be averaged. If a difference of more than 1°F is measured between the two sensors, an alarm shall be registered at the operator's workstation.
  2. A minimum of two [2] outdoor air humidity sensors shall be provided. The humidity measurements from the two sensors shall be averaged. If a difference of more than 2% RH is measured between the two sensors, an alarm shall be registered at the operator's workstation.
  3. A minimum of two [2] outdoor air CO2 sensors shall be provided. The CO2 measurements from the two sensors shall be averaged. If a difference of more than 30 ppm is measured between the two sensors, an alarm shall be registered at the operator's workstation.
- B. DDC Input/Output Points for Miscellaneous Points
  1. AI Outdoor Air Temperature [2 each]
  2. AI Outdoor Air Relative Humidity [2 each]
  3. AI Outdoor CO2 [2 each]

**END OF SECTION 23 0993**



## **SECTION 23 2113 - HYDRONIC 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
  - 1. Condenser water piping.
  - 2. Condensate drain piping.
  - 3. Blowdown drain piping.

#### **1.3 PERFORMANCE REQUIREMENTS**

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
  - 1. Condensate Drain Piping: 150°F.
  - 2. Blowdown Drain Piping: 200°F.

#### **1.4 SUBMITTALS**

- A. Product data - for each type of the following:
  - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow control valves.
  - 2. Air control devices.
  - 3. Hydronic specialties.
- B. Shop Drawings:
  - 1. Detail, at 1/4 (1:50) 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.
  - 2. Diagrams depicting the components and installation of service valves, strainers, control valves, balance valves, P&T taps, air vents, and flexible connectors applicable to each piece of terminal equipment, heat exchanger, or air coil.
- C. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

## **1.5 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.

## **PART 2 - PRODUCTS**

### **2.1 COPPER TUBE AND FITTINGS**

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Copper or Bronze Pressure-Seal Fittings:
  - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. Stadler-Viega.
  - 2. Housing: Copper.
  - 3. O-Rings and Pipe Stops: EPDM.
  - 4. Tools: Manufacturer's special tools.
  - 5. Minimum 200-psig working-pressure rating at 250°F.
- D. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
  - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. T-DRILL Industries Inc.
- E. 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, and one of the following types:
  - 1. Type E - electric resistance welded, heat treated and normalized, grades A or B, and wall thickness as indicated in Part 3 "Piping Applications" article.
  - 2. Type S - seamless, grades A or B, and wall thickness as indicated in Part 3 "Piping Applications" article.

- B. Cast iron Threaded Fittings: ASME B16.4; Classes 125 as indicated in Part 3 "Piping Applications" article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 as indicated in Part 3 "Piping Applications" article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150 as indicated in Part 3 "Piping Applications" article.
- E. Cast iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125 raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
  - 1. Material Group: 1.1.
  - 2. End Connections: Butt welding.
  - 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

## 2.3 JOINING MATERIALS

- A. Pipe Flange Gasket Materials: Thickness, material, and type of gasket shall be suitable for chemical and thermal conditions of fluid to be handled and, for working temperatures and pressures of fluid to be handled.
  - 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. 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.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

## 2.4 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°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 (1035- or 2070-kPa) 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°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 (2070-kPa) minimum working pressure at 225°F.

**2.5 VALVES**

- A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section 23 0523 "General-Duty Valves for HVAC Piping."
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section 23 0900 "Automatic Temperature 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.
  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 Gauge 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°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. 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 Gauge 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°F.

## 2.6 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 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) 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°F.

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS

#### A. Condenser water piping, aboveground, **NPS 2 (DN 50) and smaller**, shall be the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

#### B. Condenser water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

#### C. Condensate Drain Piping:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

#### D. Blowdown Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

E. Pipe Fittings:

1. Elbows: Elbows shall be constructed of the same material as the piping to which they attach. All pipe elbows shall be factory fabricated and shall have a minimum radius equal to 1.5 times the pipe diameter.
2. Tees: Tees shall be constructed of the same material as the largest pipe size to which they attach. Tees shall be factory fabricated.
  - a. Option: For copper piping, tees may be permitted to be mechanically formed.
3. Reducing Fittings: Reducers shall be constructed of the same material as the largest pipe size to which they attach. Reducers shall be tapered, having a maximum taper angle of 26.6 degrees. Abrupt-type fittings are not permissible.

### 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. Calibrated orifice, balancing valves shall not be used on equipment where pressure independent control valves are installed. Refer to Division 23 Section 230900 "Automatic Temperature Control for HVAC" for locations where calibrated orifice, balancing valves are required to be installed.
- E. Install check valves at each pump discharge and elsewhere as required to control flow direction.

### 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. Do not install piping in transformer vaults, elevator equipment rooms or electrical equipment rooms unless the piping serves HVAC equipment located in that room and is dedicated to provide cooling and/or heating to that room. Do not install piping adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.
- 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 to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- M. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- N. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- P. Install branch connections to mains using factory fabricated and/or 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.
- Q. Install valves according to Division 23 Section 23 0523 "General - Duty Valves for HVAC Piping."
- R. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
- T. Install strainers on inlet side of each control valve and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).
- U. Verify final equipment locations for roughing-in.
- V. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- W. Identify piping as specified in Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

### **3.4 HANGERS AND SUPPORTS**

- A. Hanger, support, and anchor devices are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
- B. Piping shall be supported directly from the building substrate. Pipes are not permitted to be supported from other pipes, ducts, conduits, or cable tray.



- C. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for straight runs of individual horizontal piping less than 100 feet long.
  - 2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4 (DN 20): Maximum span 7 feet; minimum rod size, 1/4 inch.
  - 2. NPS 1 (DN 25): Maximum span 7 feet; minimum rod size, 1/4 inch.
  - 3. NPS 1-1/2 (DN 40): Maximum span 9 feet; minimum rod size, 3/8 inch.
  - 4. NPS 2 (DN 50): Maximum span 10 feet; minimum rod size, 3/8 inch.
  - 5. NPS 2-1/2 (DN 65): Maximum span 11 feet; minimum rod size, 3/8 inch.
  - 6. NPS 3 (DN 80): Maximum span 12 feet; minimum rod size, 3/8 inch.
  - 7. NPS 4 (DN 100): Maximum span 14 feet; minimum rod size, 1/2 inch.
  - 8. NPS 6 (DN 150): Maximum span 17 feet; minimum rod size, 1/2 inch.
- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4 (DN 20): Maximum span 5 feet; minimum rod size, 1/4 inch.
  - 2. NPS 1 (DN 25): Maximum span 6 feet; minimum rod size, 1/4 inch.
  - 3. NPS 1-1/2 (DN 40): Maximum span 8 feet; minimum rod size, 3/8 inch.
  - 4. NPS 2 (DN 50): Maximum span 8 feet; minimum rod size, 3/8 inch.

### **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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- H. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

### **3.6 PIPING CONNECTIONS**

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
  - 3. Dry or Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

### **3.7 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.

### **3.8 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 shut-off valves and unions at each control valve to isolate for servicing of valve.
- D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections for each central station air handling unit, rooftop unit, and elsewhere as noted on the Drawings according to Division 23 Section 0519 "Meters and Gauges for HVAC Piping."

### **3.9 CHEMICAL TREATMENT**

- A. Refer to Division 23 Section 23 2513 "HVAC Water Treatment for Closed-Loop Hydronic System" for requirements.

### **3.10 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. For hydronic systems other than coil condensate drain piping, 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. For coil condensate drain piping, subject piping system to hydrostatic 15-psig test pressure. Test pressure shall not exceed maximum pressure for any component in system under test.
  6. 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.
  7. 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. 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).
  4. Set temperature controls so all coils are calling for full flow.
  5. Verify lubrication of motors and bearings.

**END OF SECTION 23 2113**

## **SECTION 23 2123 - HYDRONIC PUMPS**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Separately coupled, base mounted, end suction centrifugal pumps.
  - 2. Pump specialty fittings.

#### **1.3 DEFINITIONS**

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves. Also include dimensions, pump and motor weight, pump layout and connections, and drawings with templates for installing foundation and anchor bolts and other anchorages.
  - 1. Include diagrams for power, signal, and control wiring.
- B. Operation and Maintenance Data: For pumps to include in operation and maintenance manuals.

#### **1.5 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 for each pump.

## **PART 2 - PRODUCTS**

### **2.1 SEPARATELY COUPLED, BASE MOUNTED, END SUCTION CENTRIFUGAL PUMPS**

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps Inc.
  2. Aurora Pump; Division of Pentair Pump Group
  3. Grundfos Pumps Corporation
  4. ITT Corporation; Bell & Gossett
  5. Mepco, LLC
  6. PACO Pumps
  7. Patterson Pump Co.; a subsidiary of the Gorman-Rupp Company
  8. Peerless Pump Company
- B. Description: Factory assembled and tested, centrifugal, overhung impeller, separately coupled, end suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175 psig minimum working pressure and a continuous water temperature of 225°F.
- C. Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
  2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency drive controlled, trim impeller to match specified performance.
  3. Pump Shaft: Steel, with copper alloy shaft sleeve.
  4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and Buna-N bellows and gasket. Provide silicon carbide mechanical seals on systems circulating glycol solutions.
  5. Seal: Packing seal consisting of 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: Grease lubricated ball bearings in cast iron housing with grease fittings.
  7. Provide flush lines on pumps scheduled for variable speed operation.
- D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop out type to allow disassembly and removal without removing pump shaft or motor.
1. EPDM coupling sleeve for variable-speed applications.
- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

- G. Motor: Single speed, secured to mounting frame, with adjustable alignment.
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section 23 0513 "Common Motor Requirements for HVAC Equipment."
    - a. Enclosure: Open, drip proof.
    - b. Efficiency: Premium efficient.
  - 3. Size: Motor shall be selected for non-overloading duty across the entire pump curve that passes through the design operating point.
- H. Capacities and Characteristics: Refer to the schedule on the Drawings.

## **2.2 PUMP SPECIALTY FITTINGS**

- A. Suction Diffuser:
  - 1. Angle pattern.
  - 2. 175-psig pressure rating, cast iron body and end cap, pump-inlet fitting.
  - 3. Bronze startup and bronze or stainless steel permanent strainers.
  - 4. Bronze or stainless steel straightening vanes.
  - 5. Drain plug.
  - 6. Factory fabricated support.
- B. Triple-Duty Valve:
  - 1. Angle or straight pattern.
  - 2. 175 psig pressure rating, cast iron body, pump discharge fitting.
  - 3. Drain plug and bronze fitted shutoff, balancing, and check valve features.
  - 4. Brass gauge ports with integral check valve and orifice for flow measurement.
  - 5. Sized based on the piping size leading to the pump shown on the drawings or a maximum pressure drop of 6 ft. head at the rated design flowrate of the pump.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- B. Examine equipment foundations and anchor bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- 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. Refer to American National Standard for Rotodynamic Centrifugal Pumps for Manuals Describing Installation. Comply with HI 1.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting: Install base mounted pumps on cast-in-place concrete equipment bases. Comply with concrete requirements for equipment bases specified in Division 03.
  - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
  - 2. Construct bases to withstand, without damage to equipment, seismic force required by code.
  - 3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of base mounted pumps unless otherwise indicated.
  - 4. Install base mounted pumps on concrete equipment bases using restrained spring isolators. Refer to Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment" for restrained spring isolator requirements.
  - 5. For base mounted pumps with variable frequency drives and for base mounted pumps installed in rooms not having slab-on-grade flooring, provide an inertia base for the pump. Refer to Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment" for inertia base requirements.

### **3.3 CONNECTIONS**

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install triple-duty valve on discharge side of pumps.
- E. Install suction diffuser and shutoff valve on suction side of base mounted pumps.
- F. Install flexible connectors on suction and discharge sides of base mounted pumps between pump casing and valves.
- G. Install pressure gauges on pump suction and discharge.
- H. Ground equipment according to requirements described in Division 26.
- I. Connect wiring according to requirements described in Division 26.

### **3.4 ALIGNMENT**

- A. Engage a factory authorized service representative to perform alignment service.

- B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

### **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 23 2123**



## **SECTION 23 2513 - WATER TREATMENT FOR CLOSED LOOP HYDRONIC SYSTEM**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section includes the following water treatment for closed loop hydronic systems:
  - 1. Manual and automatic chemical feed equipment.
  - 2. Chemicals.

#### **1.3 DEFINITIONS**

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote control, signaling power limited circuits.
- B. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

#### **1.4 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. A report shall be supplied to the General Contractor, Architect and Engineer documenting that the Water Treatment Service Provider analyzed the project's incoming site water describing its characteristics.
- C. The pre-cleaning and flushing of the systems must be done with the oversight of the Water Treatment Service Provider. It must also be documented in a formal report supplied to the General Contractor, Architect and Engineer, documenting the steps taken during pre-cleaning and flushing, the water analyses done during each of the steps and a final flushing water quality analysis with particle size distribution analyses being conducted on the final flush water.
- D. The formal report shall also document the quality of the treated system. The quality of the treated water or glycol fluid must meet the specifications set forth by the HVAC equipment manufacturer, if there are any. If no such specifications exist for the equipment a full analysis must be done, including a particle size distribution analysis that documents the quality of the water/fluid. When glycol is required in the project the full analysis must include organic acidity, glycol degradation products, corrosion inhibitors, scale

promoters, contaminants, corrosion by-products and general qualities of the glycol including concentration, type and freeze point.

- E. The water chemistry and quality of the chemical treatment program will influence the corrosion rates of the system. These shall be measured by corrosion coupons using un-passivated coupons and following the ASTM procedures for monitoring corrosion rates. A 30-day coupon installed after cleaning, flushing and treatment of the system should yield the following results for the closed loop systems being treated with a formal report being issued to the general contractor and project engineer:

1. Carbon Steel (C101): Less than or equal to 0.2 mpy.
2. Copper (CDA110): Less than or equal to 0.1 mpy.

Note: These rates assume that the metal loss is uniform with no pitting or localized attack including gouging, etching, microbial attack or crevice attack. Conditions such as those are not acceptable. If they are noted the cause should be addressed with follow-up testing to confirm improvement. Localized attack at the coupon holder may be ignored if the treatment is unable to interact with the coupon in this area and no other abnormalities are noted.

- F. The water chemistry and quality of the chemical treatment program will influence the biological growth in the system. This shall be measured by Biological Dip Slides, SRB and IRB analyses. All protocols should yield a non-detectable biological growth. A formal report shall be issued to the General Contractor, Architect and Engineer to provide evidence of this.
- G. The corrosion rates in the system must be maintained at the above levels for the full year of service. They must be monitored quarterly for the first year and documented in reports sent to the Architect, Engineer and the Owner's Facility Manager.
- H. The biological growth rates in the system must be maintained at non-detectable levels for the full year of service. They must also be monitored quarterly for the first year and documented in reports sent to the Architect, Engineer and the Owner's Facility Manager.
- I. A full water or fluid analysis on each closed loop system must be done semi-annually, including a particle size distribution analysis, during the first year of service. When glycol is required in the project, the full analysis must include organic acidity, glycol degradation products, corrosion inhibitors, scale promoters, contaminants, corrosion by-products and general qualities of the glycol including concentration, type and freeze point. The findings of each analysis shall be documented and submitted in a report sent to the Architect, Engineer and the Owner's Facility Manager.

## **1.5 SUBMITTALS**

- A. Product Data: Include rated capacities; water pressure drops; shipping, installed, and operating weights; and furnished products listed below. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Chemical test equipment.
  2. Chemicals.
  3. Chemical material safety data sheets.
- B. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water treatment service provider.
- C. Water Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" article.

- D. Water Analysis and Formal Reports: Refer to the "Performance Requirements" article in this Section for water analysis and formal report requirements.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- F. Operation and Maintenance Data: For sensors, injection pumps, filters, system controls, and accessories to include in emergency, operation, and maintenance manuals specified in Division 01.

## **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.

## **1.7 MAINTENANCE SERVICE**

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic 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 WATER TREATMENT SERVICE PROVIDER**

- A. Acceptable Water Treatment Service Providers - subject to compliance with requirements, provide water treatment services by one of the following:
  - 1. Capitol Technologies, Inc. (located in McKeesport, PA).
  - 2. Chem Aqua
  - 3. Craft Products Company (located in Pittsburgh, PA).
  - 4. GLA Consultants

### **2.2 CHEMICAL TREATMENT TEST EQUIPMENT**

- A. Test Kit: Manufacturer recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, hardness, and percentage of glycol.
- B. Four Station - Corrosion Coupon Test Rack and Assembly: Constructed of corrosion resistant material, complete with piping, valves, strainer, flow monitoring gauge, quick disconnect O-ring sealed coupon holders, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test coupon assembly.

## 2.3 CHEMICALS

- A. Chemicals shall be furnished and installed as recommended by the Water Treatment Service Provider that are compatible with piping system components and connected equipment, and that can attain water quality specified in the "Performance Requirements" article in this Section.
- B. Hydrostatic Test Inhibitor: All hydrostatic test water shall contain a corrosion inhibitor package and biocide provided by the Water Treatment Service Provider to protect the system from corrosion and biological growth during stagnant periods or draining. This inhibitor package must be added during all hydrostatic testing. (NOTE: THE WATER TREATMENT SERVICE PROVIDER MUST VERIFY THAT THE HYDROSTATIC TESTING INHIBITOR PACKAGE SUPPLIED AND USED IS COMPATIBLE WITH THE EQUIPMENT CONNECTED TO THE SYSTEM.)
- C. System Cleaner: System cleaner shall be provided as recommended by the Water Treatment Service Provider and equipment manufacturer(s) to remove grease and petroleum products, flash rusting agents and other particulate in the system. (NOTE: THE WATER TREATMENT SERVICE PROVIDER MUST VERIFY THAT THE SYSTEM CLEANER USED IS COMPATIBLE WITH THE EQUIPMENT CONNECTED TO THE SYSTEM.)
- D. Closed loop Water Piping Chemicals: Closed loop water piping chemicals shall be provided as recommended by the Water Treatment Service Provider and equipment manufacturer(s) to reduce deposits, inhibit corrosion and control biological growth. It also must comply with the system water quality performance requirements specified in the "Performance Requirements" article in this Section. This product is for use during the time between flushing and glycol addition to keep the system from corroding and from bacteria from growing. (NOTE: THE WATER TREATMENT SERVICE PROVIDER MUST VERIFY THAT THE SYSTEM CORROSION INHIBITORS AND BIOCIDES ARE COMPATIBLE WITH THE EQUIPMENT CONNECTED TO THE SYSTEM.)
- E. Anti-freeze Solution: For the HVAC system(s) identified in Part 3 of this Section, furnish and install the proper amount of inhibited propylene glycol hydronic fluid to achieve a **30%** propylene glycol-water solution by volume. The inhibited propylene glycol hydronic fluid with the integral inhibitor package supplied by the manufacturer shall only be one that is manufactured for HVAC systems and **shall not** be an industrial grade glycol with a secondary inhibitor package added by the Water Treatment Service Provider. All dilution water for the glycol/hydronic fluid must be deionized water. (NOTE: THE WATER TREATMENT SERVICE PROVIDER MUST VERIFY THAT THE GLYCOL OR HYDRONIC FLUID IS COMPATIBLE WITH THE EQUIPMENT CONNECTED TO THE SYSTEM.)

## PART 3 - EXECUTION

### 3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at the Project site and to determine the type and quantities of chemicals needed to maintain the water quality as specified in "Performance Requirements" article of each closed loop system on the project.
- B. Prepare and submit documented reports to the General Contractor, Architect and Engineer as specified in "Performance Requirements" article in this Section.

### 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. For each system included in this specification, a water meter shall be used the first time it is filled to determine the exact volume, in gallons, that the system holds. All hydrostatic test water shall contain a corrosion inhibitor and biological treatment to protect the system from corrosion, flash rusting and biological growth during stagnant periods or draining. The volume of each system shall be recorded and provided to the Water Treatment Service Provider, the Architect and the Engineer. In addition, the volume of each system shall be recorded and included in the Operating and Maintenance Manuals.
- C. Prior to treating the system, thoroughly and completely clean the entire hot water and chilled water systems of all dirt and debris. Cleaning shall consist of the following procedure:
  - 1. Step 1: Fill the closed loop system with hydrostatic test water. All hydrostatic test water shall contain a corrosion inhibitor to prevent corrosion and biological growth. If any portion of the system is subject to freezing temperatures at the time of the cleaning, postpone the cleaning procedure until weather permits or verify pumps can be kept continuously running during that time period.
  - 2. Step 2: Add cleaning chemicals in sufficient quantity as recommended by the Water Treatment Service Provider.
  - 3. Step 3: Circulate solution throughout entire system for a minimum of 96-hours with filtration. Every 24 hours, check bag filter to determine how much dirt it has collected during that period. Clean or replace bag as necessary. Continue circulation process until bag filter in filter feeder is clean after the prior 24-hour circulation period.
  - 4. Step 4: Drain and flush the system until the cleaner is all removed from the system.
  - 5. Step 5: If the fluid being drained is dirty, repeat step 1 through step 4 until fluid being drained from system is clear. Take sample for laboratory analysis by the Water Treatment Service Provider.
  - 6. Step 6: Fill the entire system with water and the corrosion inhibitor package.
  - 7. Step 7: Remove all air from system.
  - 8. Step 8: Add the proper amount of chemicals as recommended by the Water Treatment Service Provider to reduce deposits, inhibit corrosion, and bring the water quality within the specified limits as recommended by the Water Treatment Service Provider.
  - 9. Circulate the system with filtration on-line to verify the system is clean. After 96-hours take a sample for laboratory analysis by the Water Treatment Service Provider.
  - 10. If glycol is to be added, only drain the system 12-hours before the glycol is to be added to prevent flash rusting. After the glycol is added and all the air is removed, circulate the system with filters installed in the filter feeder. Change the bags in the filter feeder every 24-hours until the bag filters come out clean. Take sample for laboratory analysis by the Water Treatment Service Provider.
- D. Install water testing equipment on wall near water chemical application equipment.
- E. Install interconnecting control wiring for chemical treatment controls and sensors.
- F. Mount sensors **and injectors** in piping circuits.

### 3.3 CHEMICAL TREATMENT OF SYSTEMS

- A. System Cleaner - provide system cleaner for the following systems:
  - 1. Condenser water closed loop system.

- B. Closed loop, Water Piping Chemicals - provide closed loop water piping chemicals for the following systems:
  - 1. Condenser water closed loop system.
- C. Anti-freeze Solution - provide an anti-freeze solution for the following closed loop systems:
  - 1. Condenser water closed loop system.

### **3.4 CONNECTIONS**

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Division 23 Section 23 2113 "Hydronic Piping."
- D. Install shutoff valves on HVAC water treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section 23 0523 "General-Duty Valves for HVAC Piping."
- E. Comply with requirements in Division 22 for backflow preventers required in makeup-water connections to potable-water systems.

### **3.5 FIELD QUALITY CONTROL**

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. Inspect field assembled components and equipment installation, including piping and electrical connections.
  - 2. Confirm that the water system piping has been tested and is free of leaks before cleaning system piping.
  - 3. 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.
  - 4. Place HVAC water treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
  - 5. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
  - 6. 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.
  - 7. 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.
  - 8. 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.
  - 9. Repair leaks and defects with new materials and retest piping until no leaks exist.

- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. At eight-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. Acidity and Alkalinity: ASTM D 1067.
  - 3. Iron: ASTM D 1068.
  - 4. Water Hardness: ASTM D 1126.

### **3.6 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water treatment systems and equipment. Include the following in the training:
  - 1. Review procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and closed water systems.
  - 2. Review manufacturer's safety data sheets for handling of chemicals.
  - 3. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1.
- B. Schedule at least four (4) hours of training with Owner, through the Architect, with at least seven days' advance notice.

### **END OF SECTION 23 2513**

## **SECTION 23 3113 - METAL 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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes
  - 1. Single-wall rectangular ducts and fittings.
  - 2. Single-wall round ducts and fittings.
  - 3. Sheet metal materials.
  - 4. Duct liner.
  - 5. Sealants and gaskets.
  - 6. Hangers and supports.

#### **1.3 PERFORMANCE REQUIREMENTS**

- A. 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 the "Duct Schedule" article in this Section.

#### **1.4 SUBMITTALS**

- A. Product data for each type of the following products:
  - 1. Liners and adhesives.
  - 2. Sealants and gaskets.
- B. Shop Drawings - plans, drawn to scale at a minimum of  $\frac{1}{4}" = 1'-0"$ , on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 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 and vibration isolation.
  13. Suspended ceiling components.
  14. Structural members to which duct will be attached.
  15. Size and location of ceiling grid modules for acoustical tile.
  16. Items penetrating finished ceiling including the following:
    - a. Lighting fixtures.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Sprinklers.
    - e. Access panels.
    - f. Bulkheads.
    - g. Perimeter moldings.
- C. Welding certificates.
- D. Field quality control reports.

## **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.
- B. 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."
- C. 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."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 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.

- 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."
- 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."
- D. 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."

## 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. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G90 (Z275).
  - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
  - 1. Where black and galvanized steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- 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.

## 2.4 DUCT LINER

- A. Fibrous Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. CertainTeed Corporation; Insulation Group
    - b. Johns Manville
    - c. Knauf Insulation
    - d. Owens Corning

2. Thickness and Minimum R-Value:
    - a. Ductwork Installed Indoors:
      - 1) Minimum thickness: 1½-inches.
      - 2) Minimum Installed R-value: 5.0 at 75°F mean temperature.
      - 3) The minimum thickness may be reduced provided the manufacturer's literature indicates, for the thickness supplied, an R-Value which meets or exceeds 6.0 at 75°F mean temperature when tested in accordance with ASTM C 518.
  3. Antimicrobial Erosion Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
  4. Water Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
- B. Insulation Pins and Washers
1. Cupped Head, Capacitor discharge weld Pins: Copper or zinc coated steel pin, fully annealed for capacitor discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1½ -inch galvanized carbon steel washer.
  2. Insulation Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1½-inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
  2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
  3. Butt transverse joints without gaps, and coat joint with adhesive.
  4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
  5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
  6. Secure liner with mechanical fasteners 4-inches from corners and at intervals not exceeding 12 inches transversely; at 3-inches from transverse joints and at intervals not exceeding 18-inches longitudinally.
  7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
    - a. Fan discharges.
    - b. Intervals of lined duct preceding unlined duct.
  8. Terminate inner ducts with buildouts attached to fire damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

## 2.5 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. Also, sealants and gaskets shall conform to UL 181A for metal ducts and UL 181B for flexible air ducts and flexible air connectors.
1. Closure systems uses to seal ductwork listed and labeled in accordance with UL 181A shall be marked "181A-P" for pressure sensitive tape, "181A-M" for mastic, or "181A-H" for heat sensitive tape. Closure systems uses to seal flexible air ducts and flexible air connectors shall comply with UL 181B shall be marked "181B-FX" for pressure sensitive tape, or "181B-M" for mastic.
- B. Water Based Joint and Seam Sealant
1. Type: Vinyl Acetate.
  2. Solids Content: 69.2 percent.
  3. Weight: 11.6 .2 lbs./gallon
  4. Color: Grey.
  5. Odor: Mild/Wet; Bland/Dry.
  6. VOC: 22 gms. /ltr.
  7. Viscosity: 140,000-180,000 CPS # 7 Brookfield, 20 RPM at 70°F.
  8. Flammability: Non-Flammable.
  9. Effect of Freezing: No damage - 3 Cycles.
  10. Service: Indoor and outdoor use.
  11. Storage Life: 6 Months at 70°F.
  12. Cure Time: 48 hours.
  13. Method of Application:
    - a. Brush, trowel, putty knife or caulking gun.
  14. Product: Sealant shall be equivalent to Duro Dyne DDS-181.
- C. 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.
- D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

## 2.6 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium plated steel rods and nuts.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports:

1. Supports for Galvanized steel Ducts: Galvanized steel shapes and plates.

## **PART 3 - EXECUTION**

### **3.1 DUCTWORK - GENERAL**

- A. Dimensions of ductwork shown/noted on the Drawings indicate inside clear dimensions and do not account for duct liner. When duct liner is indicated to be provided in accordance with this Section of the Specifications and/or in accordance with Division 23 Section "HVAC Insulation," the size of the duct shall be increased to accommodate the thickness of the duct liner.
- B. Do not install ductwork in transformer vaults, elevator equipment rooms or electrical equipment rooms unless the ductwork serves HVAC equipment located in that room and is dedicated to provide cooling and/or heating to that room. Do not install ductwork adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.

### **3.2 PROTECTION OF DUCT**

- A. Immediately after fabrication, the duct shall be cleaned of all dirt, dust and debris. The ends of the duct section shall then be securely covered with plastic and strapping tape. The duct shall then be completely covered with cloth or plastic.
- B. When each duct section transported to the job site, the covering over the ends of each duct shall be maintained to prevent the entrance of dirt, dust and debris. In addition, all ducts shall be covered with plastic or cloth.
- C. Immediately after the duct arrives at the job site and prior to being installed, the covering over the ends of each duct shall be maintained to prevent the entrance of dirt, dust and debris. In addition, all ducts shall be covered with plastic or cloth.
- D. When each duct is installed, the plastic covering shall be removed. Once installed, the duct section shall be inspected for the existence of dirt or dust; if discovered, the duct section shall be cleaned of all dirt and dust. Unless the next section of duct is in the process of being installed, the end of the duct shall be securely covered with plastic and strapping tape.

### **3.3 DUCT INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.

- D. Install ducts with fewest possible joints.
- E. Install factory or shop fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a minimum clearance of 1 inch plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section 23 3300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

### **3.4 DUCT SEALING**

- A. Seal ducts for duct static pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Closure systems used to seal metal ductwork shall be installed in accordance with the manufacturer's installation instructions.
- C. Unlisted duct tape is not permitted as a sealant on any metal ducts.
- D. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened.
  - 1. Mechanical fasteners for use with flexible non-metallic air ducts shall comply with UL 181B and shall be marked "181B-C."

### **3.5 HANGER AND SUPPORT INSTALLATION**

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Ducts shall be supported directly from the building substrate. Ducts are not permitted to be supported from other ducts, pipes, conduits, or cable tray.
- C. Building Attachments: Structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.

- D. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "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.
- E. Hangers Exposed to View: Threaded rod and angle or channel supports.
- F. 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 interval of 16 feet.
- G. 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.

### **3.6 CONNECTIONS**

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### **3.7 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.

### **3.8 DUCT SCHEDULE**

- A. Duct Material - fabricate ducts with galvanized sheet steel except as otherwise indicated on the Drawings.
- B. Duct Pressure Class, SMACNA Seal Class, and SMACNA Leakage Class: Fabricate ducts for the following pressure, seal and leakage classes:
  - 1. Supply air Ducts, Constant Air Volume System:
    - a. Pressure Class: Positive 2-inches wg.
    - b. Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: 24.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
  - 2. Supply air Ducts, Variable Air Volume System, Upstream of Terminal Boxes:
    - a. Pressure Class: Positive 3-inches wg.
    - b. Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 6.
  - 3. Supply air Ducts, Variable Air Volume System, Downstream of Terminal Boxes:
    - a. Pressure Class: Positive 2-inches wg.
    - b. Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: 24.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.

- 4. Return air Ductwork:
  - a. Pressure Class: Negative 2-inches wg.
  - b. Seal Class: C.
  - c. SMACNA Leakage Class for Rectangular: 24.
  - d. SMACNA Leakage Class for Round and Flat Oval: 12.
    - 1) and Flat Oval: 12.

- 5. Outdoor Air Ductwork:
  - a. Pressure Class: Negative 2-inches wg.
  - b. Seal Class: C.
  - c. SMACNA Leakage Class for Rectangular: 24.
  - d. SMACNA Leakage Class for Round and Flat Oval: 12.

C. Intermediate Reinforcement:

- 1. Galvanized steel Ducts: Match duct material.

D. Duct Liner Application: Fabricate ducts with duct liner as described below except as otherwise indicated on the Drawings. Refer to Division 23 Section "HVAC Insulation" for additional requirements.

- 1. Return air ducts extending from the unit intake to a location 30-feet upstream of the unit intake:

**END OF SECTION 23 3113**



## **SECTION 23 3300 - AIR DUCT ACCESSORIES**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes
  - 1. Manual volume dampers.
  - 2. Control dampers.
  - 3. Flange connectors.
  - 4. Turning vanes.
  - 5. Duct mounted access doors.
  - 6. Flexible connectors.
  - 7. Flexible ducts.
  - 8. Duct accessory hardware.

#### **1.3 SUBMITTALS**

- A. Product Data - submit manufacturer's published data for each type of product indicated.
  - 1. Manual volume dampers.
  - 2. Control dampers.
  - 3. Flange connectors.
  - 4. Turning vanes.
  - 5. Duct mounted access doors.
  - 6. Flexible connectors.
  - 7. Flexible ducts.
  - 8. Duct accessory hardware.
- B. Coordination Drawings: Refer to Division 23 Sections 23 0500 "Common Work Results for HVAC" and Section 23 3113 "Metal Ducts" for coordination drawing requirements. Show all duct accessories on coordination drawings. Also, include access panels and access doors required for access to duct accessories on coordination drawings.
- C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

## **1.4 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.

## **1.5 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, but not less than 5.

## **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 (Z275).
  - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- 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.

### **2.2 MANUAL VOLUME DAMPERS**

- A. Standard, Steel, Manual Volume Dampers
  - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
    - a. Air Balance Inc.; a division of Mestek, Inc.
    - b. American Warming and Ventilating; a division of Mestek, Inc.
    - c. Elgen
    - d. Flexmaster U.S.A., Inc.
    - e. McGill AirFlow LLC.
    - f. METALAIRE, Inc.
    - g. Nailor Industries Inc.
    - h. Pottorff; a division of PCI Industries, Inc.
    - i. Ruskin Company.
    - j. Vent Products Company, Inc.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:
  - a. Hat-shaped, galvanized steel channels, 0.064-inch minimum thickness.
  - b. Mitered and welded corners.
  - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
  - a. Multiple or single blade.
  - b. Parallel- or opposed-blade design.
  - c. Stiffen damper blades for stability.
  - d. Galvanized steel, 0.064 inch thick.
6. Blade Axles: Galvanized steel or stainless steel.
7. Bearings:
  - a. Oil impregnated bronze bearings, molded synthetic bearings or 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. Tie Bars and Brackets: Galvanized steel.

## **2.3 CONTROL DAMPERS**

- A. Control dampers shall be furnished by the Automatic Temperature Control Subcontractor. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for requirements.

## **2.4 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. Gauge and Shape: Match connecting ductwork.

## **2.5 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. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall.

## 2.6 DUCT MOUNTED ACCESS DOORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating; a division of Mestek, Inc.
  - 2. Cesco Products; a division of Mestek, Inc.
  - 3. Ductmate Industries, Inc.
  - 4. Elgen
  - 5. Flexmaster U.S.A., Inc.
  - 6. Greenheck Fan Corporation
  - 7. McGill AirFlow, LLC
  - 8. Nailor Industries Inc.
  - 9. Pottorff; a division of PCI Industries, Inc.
  - 10. Ventfabrics, Inc.
  - 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
  - 1. Door:
    - a. Double wall, rectangular.
    - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    - c. Vision panel.
    - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
    - e. Fabricate doors airtight and suitable for duct pressure class.
  - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
  - 3. Number of Hinges and Locks:
    - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
    - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
    - d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

## **2.7 DUCT ACCESS PANEL ASSEMBLIES**

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.
  - 2. Flame Gard, Inc.
  - 3. 3M
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon-steel where duct access panel assemblies are installed in carbon-steel ducts. Minimum thickness 0.0428-inch stainless steel where duct access panel assemblies are installed in stainless steel ducts.
- D. Fasteners: Carbon-steel for carbon-steel duct access panel assemblies; stainless steel for stainless steel duct access panel assemblies. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000°F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

## **2.8 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 having a minimum width of 5-3/4 inches attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd.
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40° to plus 200°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°F.

G. High Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67° to plus 500°F.

## **2.9 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°F.

C. Flexible Duct Connectors

1. Clamps: Nylon strap in sizes 3 through 18 inches to suit duct size.

## **2.10 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 control 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. Install volume dampers a minimum of 5-feet from the diffuser, register or grille in which it is controlling airflow. 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. Volume damper shall be constructed of the same material as the duct in which it is to be installed.
- E. Install turning vanes in all mitered rectangular duct elbows with an angle greater than 45°.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. On both sides of duct coils.
  - 2. Upstream and downstream from duct filters.
  - 3. At outdoor-air intakes and mixed-air plenums.
  - 4. At drain pans.
  - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
  - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
  - 7. At each change in direction and at maximum 50-foot spacing.
  - 8. Upstream from turning vanes.
  - 9. Upstream or downstream from duct silencers.
  - 10. Control devices requiring inspection.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes: Access doors shall be sized as large as possible and practical, but shall not be less than 12 x 6 inches and shall not be greater than 25 x 25 inches.
- K. Label access doors according to Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.
  - 1. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- M. Connect each diffuser to duct directly or with maximum 96-inch length of flexible duct clamped or strapped in place. The flexible duct shall be permitted to have a total maximum change of direction not exceeding 90-degrees.
- N. Connect flexible ducts to metal ducts with nylon draw bands.
- O. Install duct test holes where required for testing and balancing purposes.

### **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 to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

**END OF SECTION 23 3300**



## **SECTION 23 7413 - PACKAGED ROOFTOP AIR CONDITIONING UNITS**

### **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.
- B. All Division 23 Specification Sections also apply to this Section.

#### **1.2 SUMMARY**

- A. Rooftop equipment is being pre-purchased by the school through Costars and will be delivered to the site from the factory.

#### **1.3 DEFINITIONS**

- A. DDC: Direct-digital controls.
- B. ECM: Electronically commutated motor.
- C. MERV: Minimum efficiency reporting value.
- D. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, roof-mounted, central station air handling unit and packaged, outdoor, roof-mounted, air-conditioning unit.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Design RTU supports to comply with wind performance requirements.
- B. Wind Restraint Performance:
  - 1. Basic Wind Speed: 110 mph.
  - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

#### **1.5 SUBMITTALS**

- A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Structural members to which RTUs will be attached.
  - 2. Roof openings.
  - 3. Adaptive curbs.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

- D. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

## **1.6 QUALITY ASSURANCE**

### **A. AHRI Compliance:**

1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
4. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.

### **B. AMCA Compliance:**

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested in accordance with AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

### **C. ASHRAE Compliance:**

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

### **D. ASHRAE/IES 90.1 Compliance:** Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### **E. NFPA Compliance:** Comply with NFPA 90A or NFPA 90B.

### **F. UL Compliance:** Comply with UL 1995.

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

## **1.7 WARRANTY**

### **A. Special Warranty:** Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than ten (10) years from date of Substantial Completion.
3. Warranty Period for Antimicrobial Ultraviolet Lamp System: Lifetime with exception of lamps.

## PART 2 - PRODUCTS

### 2.1 ROOFTOP UNITS - RTU-1, 2, 3, 4, 5, and 6

A. Manufacturers - products shall be provided by one of the following manufacturers:

1. AAON

B. General Description

1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, water-cooled condensers, reheat coil, gas heaters, electric heaters, exhaust fans, energy recovery wheels, and unit controls.
2. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
6. Installation, Operation and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.
9. Options:
  - a. Unit shall be crated for overseas shipment. Crate shall be fabricated from blocked, braced, and banded dimensional lumber and plywood.

C. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

6. Access to filters, dampers, cooling coils, reheat coil, heaters, exhaust fans, energy recovery wheels, compressors, water-cooled condensers, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall include lifting lugs on the top of the unit.
11. Options:
  - a. Unit shall include interior corrosion protection which shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure. Air tunnel, fans, dampers, and economizer shall all include the corrosion protection.
  - b. Unit base pan shall be provided with 1/2-inch-thick foam insulation.
  - c. Unit shall include factory wired control panel compartment LED service lights.
  - d. Unit shall include factory installed, painted galvanized steel condenser coil guards on the face of the condenser coil.

#### D. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.
2. Options:
  - a. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
  - b. Unit shall be provided with factory installed and field wired 115V, 20-amp GFI outlet in the unit control panel.
  - c. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.
  - d. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.
  - e. Unit shall be provided with blower auxiliary contacts on the low voltage terminal block which close when the supply fans are energized.
  - f. Unit shall be provided with remote stop/start terminals which require contact closure for unit operation. When these contacts are open the low voltage circuit is broken and the unit will not operate.

#### E. Supply Fans

1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
2. Blowers and motors shall be dynamically balanced and mounted on rubber isolators.
3. Motors shall be standard (premium) efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Options:
  - a. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

F. Exhaust Fans

1. Exhaust dampers shall be sized for 100% relief.
2. Fans and motors shall be dynamically balanced.
3. Motors shall be standard (premium) efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn handles.
5. Options:
  - a. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

G. Cooling Coils

1. Evaporator Coils:
  - a. Coils shall be designed for use with R-454B or R-32 refrigerant and constructed of copper tubes with aluminum (copper) fins mechanically bonded to the tubes and galvanized (304 stainless) steel end casings. Fin design shall be sine wave rippled.
  - b. Coils shall have interlaced circuitry and shall be standard (6 row high) capacity.
  - c. Coils shall be helium leak tested.
  - d. Coils shall be furnished with a factory installed thermostatic expansion valves.

H. Refrigeration System

1. Unit shall be factory charged with R-454B or R-32 refrigerant.
2. Compressors shall be scroll type with thermal overload protection, independently circuited, and carry a 5-year non-prorated warranty.
3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.
4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
5. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.
6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low-pressure sides, and factory installed liquid line filter driers.
7. Options:
  - a. Unit shall include a variable capacity scroll compressor on the lead (all) refrigeration circuit(s) which shall be capable of modulation from 10-100% of its capacity.
  - b. Lead refrigeration circuit(s) shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
  - c. Unit shall be configured as a water-source heat pump. Each refrigeration circuit shall each be equipped with a factory installed liquid line filter drier with check valve, reversing valve, and thermal expansion valves on both the indoor coil and refrigerant-to-water heat exchanger. Reversing valve shall energize during the heat pump heating mode of operation.

- d. Each refrigeration circuit shall be equipped with a liquid line sight glass.
- e. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.
- f. Each capacity stage shall be equipped with a 5 minute off, delay timer to prevent compressor short cycling.
- g. Each capacity stage shall be equipped with an adjustable, 20 second delay timer to prevent multiple capacity stages from starting all at once.
- h. Lead refrigeration circuit shall be provided with hot gas reheat coil, on/off control valves and a control signal terminal which allow the unit to have a dehumidification mode of operation.
- i. Each refrigeration circuit shall include adjustable compressor lockouts.
- j. First capacity stage shall be provided with on/off condenser fan cycling and adjustable compressor lockout to allow cooling operation down to 35°F.
- k. Lead refrigeration circuit shall be equipped with flooded condenser low ambient head pressure control to allow operation down to 0°F. Option includes on/off condenser fan cycling and adjustable compressor lockout.
- l. Each refrigeration circuit shall be provided with an adjustable temperature sensor freeze stat which shuts down the cooling circuits when the evaporator coil tubing falls below the setpoint.

#### I. Condensers

##### 1. Water-Cooled Condenser:

- a. Water-cooled condensing section shall contain plate type, heat exchangers located in an insulated vestibule. Heat exchangers shall be circuited in a counter flow arrangement to the refrigerant system. Plates shall be stainless steel.  
Each heat exchanger shall be provided with a removable and cleanable type, basket filter on the waterside circuit. Field piping connections shall be made at each plate heat exchanger within the condensing section of the rooftop unit. Maximum operating pressure on the water side of the condenser shall be 125 psi.
- b. All field installed piping shall be hydrostatically tested before being put into service. Test pressure shall be 125 psi for a two-hour duration. Leaks and loss in test pressure constitute defects. If test fails, corrections shall be made to the system and the test shall then be repeated to make certain all defects were corrected. All testing shall be performed to ASTM Standards.
- c. Options:
  - 1) Each heat exchanger circuit shall have a factory installed ball valve for water balancing.
  - 2) Each heat exchanger circuit shall have a flow switch that shuts down the compressors if water flow to the condenser is interrupted.
  - 3) Each heat exchanger circuit shall have a factory installed motorized shutoff valve.
  - 4) Unit shall include factory installed head pressure control module and each heat exchanger shall include factory installed head pressure control valve which modulates the condenser water flow based on head pressure and allows cooling operation below 65°F condenser water temperature.

#### J. Electric Heating

- 1. Unit shall include an include electric heater consisting of electric heating coils, fuses, and a high temperature limit switch, with capacities as shown on the plans.
- 2. Unit shall include modulating heating capacity.

3. Electric heating coils shall be located in the reheat position downstream of the supply fans.
4. Options:
  - a. RTU-1, 2, 5, and 6: Electric heater shall have full modulation capacity controlled by an SCR (Silicon Controlled Rectifier). A 0-10 VDC heating control signal shall be field provided to control the amount of heating.
  - b. RTU-1 and 2: Auxiliary electric heating capacity shall be sized to meet heating leaving air temperature setpoint when heat pump heating is in operation. Auxiliary heating capacity shall be available for operation when heat pump heating is in operation. Unit shall include modulating auxiliary electric heating capacity. [Heat Pump - Auxiliary Heat Sizing]
  - c. RTU-5 and 6: Emergency electric heating capacity shall be sized to meet heating leaving air temperature setpoint when heat pump heating is not in operation. Auxiliary electric heating capacity shall be sized to meet heating leaving air temperature setpoint when heat pump heating is in operation. Unit shall include 1 (2) (4) stages of auxiliary electric heating capacity. [Heat Pump - Emergency Heat Sizing]

K. Electric Preheat Coils at RTU-1, 2, 5, and 6

1. Unit shall include an include pre-electric heater consisting of electric heating coils, fuses, and a high temperature limit switch, with capacities as shown on the plans.
2. Unit shall include modulating heating capacity.
3. Electric heating coils shall be located in the pre-heat position upstream of the energy recovery wheel, outside air intake.

L. Filters

1. Unit shall include 4-inch thick, pleated panel filters with an ASHRAE efficiency of 85% and a MERV rating of 13, upstream of the cooling coil. Unit shall also include 2-inch thick, pleated panel pre filters with a MERV rating of 8, upstream of the 4-inch standard filters.
2. Unit shall include a clogged filter switch.
3. Unit shall include a Magnehelic gauge mounted in the controls compartment.

M. Outside Air/Economizer RTU-1, 2, 3, 4, 5, and 6

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper.
2. Damper assembly shall be controlled by spring return, fully modulating DDC actuator. Unit shall include outside air opening bird screen, outside air hood with rain lip and barometric relief dampers.
3. Options:
  - a. Economizer shall be furnished with return air CO2 override.
  - b. Economizer shall be furnished with the Constant Volume Outside Air ventilation control assembly which maintains a minimum amount of entering outside air. It shall measure the outside air velocity pressure and adjust the economizer dampers to maintain a constant velocity pressure and thus a constant volume of outside air.
4. Control of economizer shall be as described in section 23 0993 Sequence of Operations for HVAC Control.

#### N. Energy Recovery

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.
2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning.  
Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
7. Energy recovery wheel cassette shall carry a 5-year non-prorated warranty.
8. Unit shall include 4-inch thick, pleated panel outside air filters with an ASHRAE efficiency of 30% and MERV rating of 7, upstream of the wheels. (Unit shall include 2-inch thick, pleated panel outside air and exhaust air filters with an ASHRAE efficiency of 30% and MERV rating of 7, upstream of the wheels.)
9. Hinged service access door shall allow access to the wheel(s).
10. Options:
  - a. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
11. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation.

#### O. Controls

1. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.



- a. A programmable controller shall be provided by the ATC subcontractor to control those actions as described in Section 23 0993 Sequence of Operations” for HVAC Control.
- b. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.
- c. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
- d. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and natural gas heat as applicable.
- e. Sensors:
  - 1) Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.
  - 2) Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.

P. Accessories

1. Unit shall be provided with a terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

## 2.2 OUTSIDE AIR UNITS: OAU-1, 2, 3, and 4

A. Manufacturers - products shall be provided by one of the following manufacturers:

1. AAON
2. Substitute equipment by one of the manufacturer's listed below may be considered for approval that includes at a minimum:
  - a. R-410A refrigerant
  - b. Direct drive supply fans
  - c. Double wall cabinet construction
  - d. Insulation with a minimum R-value of 12
  - e. Stainless steel drain pans
  - f. Hinged access doors with lockable handles
  - g. Variable capacity compressor with 10-100% capacity
3. Addison Products Company
4. Carrier Corporation
5. Daikin McQuay
6. Trane; American Standard Companies, Inc.
7. Valent
8. YORK International Corporation

B. General Description

1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, water-cooled condensers, reheat coil, gas heaters, electric heaters, exhaust fans, energy recovery wheels, and unit controls.

2. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
6. Installation, Operation and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.
9. Options:
  - a. Unit shall be crated for overseas shipment. Crate shall be fabricated from blocked, braced, and banded dimensional lumber and plywood.

C. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, reheat coil, heaters, exhaust fans, energy recovery wheels, compressors, water-cooled condensers, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall include lifting lugs on the top of the unit.
11. Options:
  - a. Unit shall include interior corrosion protection which shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure. Air tunnel, fans, dampers, and economizer shall all include the corrosion protection.

- b. Unit base pan shall be provided with 1/2-inch-thick foam insulation.
- c. Unit shall include factory wired control panel compartment LED service lights.
- d. Unit shall include factory installed, painted galvanized steel condenser coil guards on the face of the condenser coil.

D. Electrical

- 1. Unit shall be provided with standard power block for connecting power to the unit.
- 2. Options:
  - a. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
  - b. Unit shall be provided with factory installed and field wired 115V, 20-amp GFI outlet in the unit control panel.
  - c. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.
  - d. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.
  - e. Unit shall be provided with blower auxiliary contacts on the low voltage terminal block which close when the supply fans are energized.
  - f. Unit shall be provided with remote stop/start terminals which require contact closure for unit operation. When these contacts are open the low voltage circuit is broken and the unit will not operate.

E. Supply Fans

- 1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
- 2. Blowers and motors shall be dynamically balanced and mounted on rubber isolators.
- 3. Motors shall be standard (premium) efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
- 4. Options:
  - a. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

F. Exhaust Fans

- 1. Exhaust dampers shall be sized for 100% relief.
- 2. Fans and motors shall be dynamically balanced.
- 3. Motors shall be standard (premium) efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
- 4. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn handles.
- 5. Options:
  - a. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

## G. Cooling Coils

### 1. Evaporator Coils:

- a. Coils shall be designed for use with R-454B or R-32 refrigerant and constructed of copper tubes with aluminum (copper) fins mechanically bonded to the tubes and galvanized (304 stainless) steel end casings. Fin design shall be sine wave rippled.
- b. Coils shall have interlaced circuitry and shall be standard (6 row high) capacity.
- c. Coils shall be helium leak tested.
- d. Coils shall be furnished with a factory installed thermostatic expansion valves.

## H. Refrigeration System

1. Unit shall be factory charged with R-454B or R-32 refrigerant.
2. Compressors shall be scroll type with thermal overload protection, independently circuited, and carry a 5-year non-prorated warranty.
3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.
4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
5. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.
6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low-pressure sides, and factory installed liquid line filter driers.
7. Options:
  - a. Unit shall include a variable capacity scroll compressor on the lead (all) refrigeration circuit(s) which shall be capable of modulation from 10-100% of its capacity.
  - b. Lead refrigeration circuit(s) shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
  - c. Unit shall be configured as a water-source heat pump. Each refrigeration circuit shall each be equipped with a factory installed liquid line filter drier with check valve, reversing valve, and thermal expansion valves on both the indoor coil and refrigerant-to-water heat exchanger. Reversing valve shall energize during the heat pump heating mode of operation.
  - d. Each refrigeration circuit shall be equipped with a liquid line sight glass.
  - e. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.
  - f. Each capacity stage shall be equipped with a 5 minute off, delay timer to prevent compressor short cycling.
  - g. Each capacity stage shall be equipped with an adjustable, 20 second delay timer to prevent multiple capacity stages from starting all at once.
  - h. Lead refrigeration circuit shall be provided with hot gas reheat coil, on/off control valves and a control signal terminal which allow the unit to have a dehumidification mode of operation.
  - i. Each refrigeration circuit shall include adjustable compressor lockouts.

- j. First capacity stage shall be provided with on/off condenser fan cycling and adjustable compressor lockout to allow cooling operation down to 35°F.
- k. Lead refrigeration circuit shall be equipped with flooded condenser low ambient head pressure control to allow operation down to 0°F. Option includes on/off condenser fan cycling and adjustable compressor lockout.
- l. Each refrigeration circuit shall be provided with an adjustable temperature sensor freeze stat which shuts down the cooling circuits when the evaporator coil tubing falls below the setpoint.

#### I. Condensers

##### 1. Water-Cooled Condenser:

- a. Water-cooled condensing section shall contain plate type, heat exchangers located in an insulated vestibule. Heat exchangers shall be circuited in a counter flow arrangement to the refrigerant system. Plates shall be stainless steel. Each heat exchanger shall be provided with a removable and cleanable type, basket filter on the waterside circuit. Field piping connections shall be made at each plate heat exchanger within the condensing section of the rooftop unit. Maximum operating pressure on the water side of the condenser shall be 125 psi.
- b. All field installed piping shall be hydrostatically tested before being put into service. Test pressure shall be 125 psi for a two-hour duration. Leaks and loss in test pressure constitute defects. If test fails, corrections shall be made to the system and the test shall then be repeated to make certain all defects were corrected. All testing shall be performed to ASTM Standards.
- c. Options:
  - 1) Each heat exchanger circuit shall have a factory installed ball valve for water balancing.
  - 2) Each heat exchanger circuit shall have a flow switch that shuts down the compressors if water flow to the condenser is interrupted.
  - 3) Each heat exchanger circuit shall have a factory installed motorized shutoff valve.
  - 4) Unit shall include factory installed head pressure control module and each heat exchanger shall include factory installed head pressure control valve which modulates the condenser water flow based on head pressure and allows cooling operation below 65°F condenser water temperature.

#### J. Gas Heating OAU-1, 2, 3, and 4

- 1. Unit shall include a natural gas furnace with modulating capacity.
- 2. Aluminized steel or Stainless steel heat exchanger furnace shall carry a 15 year non-prorated warranty.
- 3. Gas furnace shall consist of aluminized or stainless steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.
- 4. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
- 5. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.

6. Options:

- a. Natural gas furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the control compartment. 90 MBtu/h, 150 MBtu/h, 195 MBtu/h, 210 MBtu/h, 270 MBtu/h, 292.5 MBtu/h, 390 MBtu/h, and 540 MBtu/h gas heating assemblies shall be capable of operating at any firing rate between 100% and 30% of their rated capacity. 405 MBtu/h and 810 MBtu/h gas heating assemblies shall be capable of operating at any firing rate between 100% and 20% of their rated capacity. 1080 MBtu/h gas heating assembly shall be capable of operating at any firing rate between 100% and 15% of its rated capacity.
- b. Unit shall include a liquid propane furnace(s) with two stages of capacity.
- c. Gas heating capacity shall be sized to meet heating leaving air temperature setpoint when heat pump heating is not in operation. Gas heating capacity shall be available for operation when heat pump heating is in operation. Unit shall have a modulating gas heating capacity.

K. Filters

1. Unit shall include 4-inch thick, pleated panel filters with an ASHRAE efficiency of 85% and a MERV rating of 13, upstream of the cooling coil. Unit shall also include 2-inch thick, pleated panel pre filters with a MERV rating of 8, upstream of the 4-inch standard filters.
2. Unit shall include a clogged filter switch.
3. Unit shall include a Magnehelic gauge mounted in the controls compartment.

L. Outside Air/Economizer RTU-1, 2, 3, 4, 5, and 6

1. Unit shall include 100% motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return, 2 position actuator. Unit shall include outside air opening bird screen and outside air hood with rain lip.
2. Control of economizer shall be as described in section 23 0993 "Sequence of Operations for HVAC Control".

M. Energy Recovery

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.
2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning.

Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
7. Energy recovery wheel cassette shall carry a 5-year non-prorated warranty.
8. Unit shall include 4-inch thick, pleated panel outside air filters with an ASHRAE efficiency of 30% and MERV rating of 7, upstream of the wheels. (Unit shall include 2-inch thick, pleated panel outside air and exhaust air filters with an ASHRAE efficiency of 30% and MERV rating of 7, upstream of the wheels.)
9. Hinged service access door shall allow access to the wheel(s).
10. Options:
  - a. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
11. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation.

#### N. Controls

1. The packaged unit will be furnished "BAS ready" with a terminal strip and all internal wiring, control components, actuators, and safeties required for complete equipment operation, but without a programmable controller to control functions related to the operation of return and outside air intake dampers, supply fan on/off, supply fan speed, relief air fan on/off, and relief air fan speed.
  - a. A programmable controller shall be provided by the ATC subcontractor to control those actions as described in Section 23 0993 "Sequence of Operations for HVAC Control".
  - b. In addition to the control functions noted above, the programmable controller provided by the ATC subcontractor will enable mechanical cooling and reset the unit's supply air temperature setpoint.
  - c. The unit's supply air temperature setpoint shall be controlled by HVAC equipment manufacturer's integral controls.
  - d. The HVAC equipment manufacturer shall include all wiring, programming, control componentry and safeties necessary for control of refrigeration compressors, direct expansion cooling, modulating hot gas reheat, and natural gas heat as applicable.
  - e. Sensors:
    - 1) Sensors required by the ATC subcontractor to perform the BAS control features described above shall be furnished and field installed by the ATC subcontractor.

- 2) Sensors required by the air handling unit equipment manufacturer to perform the equipment manufacturer's control functions described above shall be furnished and factory installed by the air handling unit equipment manufacturer.

O. Accessories

1. Unit shall be provided with a terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

## 2.3 CURBS

- A. Furnish and install adaptive curbs to mate the new equipment to the existing curbs on the roof.
- B. Curbs shall to be fully gasketed between the adaptive curb top and unit bottom and the existing curb top and adaptive curb bottom, providing full perimeter support, cross structure support and air seal for the unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.
- C. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment" for wind-load requirements.

## PART 3 - EXECUTION

### 3.1 DELIVERY

- A. Equipment shall be delivered to the site from the factory by others.
- B. Contractor shall examine the equipment for defects and damage prior to unloading the equipment.
- C. Contractor shall be responsible for unloading the equipment from the delivery trucks and storing it until installation. Contractor shall coordinate the delivery of the equipment with the equipment vendor, Tobey-Karg Sales.

### 3.2 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.



### **3.3 INSTALLATION**

- A. Roof Curb: Install on roof structure, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- B. Install rooftop units according to manufacturer's written installation instructions.
- C. Equipment Mounting:
  - 1. Comply with requirements for vibration isolation devices specified in Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment."

### **3.4 CONNECTIONS**

- A. Install condensate drain, minimum connection size, with trap and drain onto a roof pad. Provide a roof pad below the outlet of the drain.
- B. Install piping adjacent to RTUs to allow service and maintenance.
  - 1. Gas Piping: Gas piping will be provided as shown on the Plumbing Drawings and as described in Division 22.
- C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
  - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 23 3300 "Air Duct Accessories."
  - 4. Install return air duct continuously through roof structure.
- D. Connect electrical wiring according to Division 26.
- E. Ground equipment according to Division 26.
- F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Refer to Division 26 for requirements.
  - 1. Locate nameplate where easily visible.

### **3.5 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. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

### 3.6 STARTUP SERVICE

A. Engage a factory authorized service representative to perform startup service.

B. Complete installation and startup check according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators. Keep shipping blocks locked in place if the unit is furnished with a vibration isolation curb.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.
  - a. Start refrigeration system.
  - b. Do not operate refrigeration system below recommended low-ambient temperature.
  - c. Complete startup sheets and attach copy with Contractor's startup report.
18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Calibrate thermostats.
21. Adjust and inspect high temperature limits.
22. Inspect outdoor air dampers for proper stroke and interlock with return air dampers.
23. Start refrigeration system and measure and record the following when ambient is a minimum of 15°F above return air temperature:
  - a. Coil leaving air, dry and wet bulb temperatures.
  - b. Coil entering air, dry and wet bulb temperatures.
  - c. Outdoor air, dry bulb temperature.
  - d. Outdoor air coil, discharge air, dry bulb temperature.

24. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
  - a. Measure gas pressure on manifold.
  - b. Inspect operation of power vents.
  - c. Measure combustion air temperature at inlet to combustion chamber.
  - d. Measure flue-gas temperature at furnace discharge.
  - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
  - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
  - a. Supply air volume.
  - b. Return air volume.
  - c. Relief air volume.
  - d. Outdoor air intake volume.
27. Simulate maximum cooling demand and inspect the following:
  - a. Compressor refrigerant suction and hot-gas pressures.
  - b. Short circuiting of air through condenser coil or from condenser fans to outdoor air intake.
28. Verify operation of failure modes. Inspect the following:
  - a. High-temperature limit on gas-fired heat exchanger.
  - b. Low temperature safety operation.
  - c. Filter high pressure differential alarm.
  - d. Economizer to minimum outdoor air changeover.
  - e. Relief/Exhaust air fan operation.
  - f. Smoke and firestat alarms.
29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

### **3.7 CLEANING AND ADJUSTING**

- A. After completing system installation and prior to testing, adjusting, and balancing RTU and air-distribution systems, clean entire unit including filter housings and install new filters.

### **3.8 DEMONSTRATION**

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Refer to Division 01 for additional requirements.
  1. Video tape training session. Provide the Owner with a DVD containing a copy of the training session.

### **END OF SECTION 23 7413**

MIDDLE SCHOOL  
HVAC EQUIPMENT REPLACEMENT AND UPGRADES

GROVE CITY AREA SCHOOL DISTRICT  
DRAW Collective Project No. 25-S43-01

## **ELECTRICAL INDEX**

<b>SECTION</b>	<b>DESCRIPTION</b>	<b>PAGE NO.</b>
26 0100	Basic Electrical Requirements	1 - 16
26 0519	Low Voltage Electrical Power Conductors and Cables	1 - 6
26 0526	Grounding and Bonding for Electrical Systems	1 - 4
26 0529	Hangers and Supports for Electrical Systems	1 - 4
26 0533	Raceways and Boxes for Electrical Systems	1 - 8
26 0544	Sleeves and Seals for Electrical Systems	1 - 9
26 0553	Identification for Electrical Systems	1 - 3
26 1900	Fire Alarm Devices	1 - 8
26 2726	Wiring Devices	1 - 5
26 2813	Fuses	1 - 4
26 2816	Enclosed Switches and Circuit Breakers	1 - 4

## **SECTION 26 0100 - BASIC ELECTRICAL REQUIREMENTS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 09 FINISHES Sections.

#### **1.2 SUMMARY**

- A. This Section includes general administrative, procedural requirements, construction materials and construction methods for electrical installations. The following requirements are included in this Section to expand the requirements specified in Division 01 - reference individual sections for further expansion of these requirements:
  - 1. Abbreviations and Acronyms
  - 2. Definitions
  - 3. Permits, Codes, and Inspections
  - 4. Visiting Premises
  - 5. Project Drawings and Specifications
  - 6. Nameplate Data
  - 7. Coordination
  - 8. Substitutions
  - 9. Submittals
  - 10. Quality Assurance and Testing
  - 11. Temporary
  - 12. Delivery, Storage, and Handling
  - 13. Cutting and Patching
  - 14. Installations
  - 15. Final Cleaning
  - 16. Warranties
  - 17. Maintenance Manuals
  - 18. Record Documents
  - 19. Demonstration and Training

#### **1.3 ABBREVIATIONS AND ACRONYMS**

- A. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.
  - 1. AAMA - American Architectural Manufacturers Association; [www.aamanet.org](http://www.aamanet.org).
  - 2. AASHTO - American Association of State Highway and Transportation Officials; [www.transportation.org](http://www.transportation.org).

3. ACI - American Concrete Institute; (Formerly: ACI International); [www.concrete.org](http://www.concrete.org).
4. AEIC - Association of Edison Illuminating Companies, Inc. (The); [www.aeic.org](http://www.aeic.org).
5. AIA - American Institute of Architects (The); [www.aia.org](http://www.aia.org).
6. AISC - American Institute of Steel Construction; [www.aisc.org](http://www.aisc.org).
7. AISI - American Iron and Steel Institute; [www.steel.org](http://www.steel.org).
8. ANSI - American National Standards Institute; [www.ansi.org](http://www.ansi.org).
9. APA - Architectural Precast Association; [www.archprecast.org](http://www.archprecast.org).
10. ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers; [www.ashrae.org](http://www.ashrae.org).
11. ASME - ASME International; (American Society of Mechanical Engineers); [www.asme.org](http://www.asme.org).
12. ASSE - American Society of Safety Engineers (The); [www.asse.org](http://www.asse.org).
13. ASTM - ASTM International; [www.astm.org](http://www.astm.org).
14. ATIS - Alliance for Telecommunications Industry Solutions; [www.atis.org](http://www.atis.org).
15. AWEA - American Wind Energy Association; [www.awea.org](http://www.awea.org).
16. BICSI - BICSI, Inc.; [www.bicsi.org](http://www.bicsi.org).
17. CDA - Copper Development Association; [www.copper.org](http://www.copper.org).
18. CEA - Consumer Electronics Association; [www.ce.org](http://www.ce.org).
19. CRSI - Concrete Reinforcing Steel Institute; [www.crsi.org](http://www.crsi.org).
20. CSA - CSA Group; [www.csa.ca](http://www.csa.ca).
21. CSA - CSA International; (Formerly: IAS - International Approval Services); [www.csa-international.org](http://www.csa-international.org).
22. CSI - Construction Specifications Institute (The); [www.csinet.org](http://www.csinet.org).
23. CPSC - Consumer Product Safety Commission; [www.cpsc.gov](http://www.cpsc.gov).
24. DASMA - Door and Access Systems Manufacturers Association; [www.dasma.com](http://www.dasma.com).
25. DHI - Door and Hardware Institute; [www.dhi.org](http://www.dhi.org).
26. DOE - Department of Energy; [www.energy.gov](http://www.energy.gov).
27. ECA - Electronic Components Association; (See ECIA).
28. ECAMA - Electronic Components Assemblies & Materials Association; (See ECIA).
29. ECIA - Electronic Components Industry Association; [www.eciaonline.org](http://www.eciaonline.org).
30. EIA - Electronic Industries Alliance; (See TIA).
31. EJMA - Expansion Joint Manufacturers Association, Inc.; [www.ejma.org](http://www.ejma.org).
32. EPA - Environmental Protection Agency; [www.epa.gov](http://www.epa.gov).
33. ESD - ESD Association; (Electrostatic Discharge Association); [www.esda.org](http://www.esda.org).
34. ESTA - Entertainment Services and Technology Association; (See PLASA).
35. ETL - Intertek (See Intertek); [www.intertek.com](http://www.intertek.com).
36. FAA - Federal Aviation Administration; [www.faa.gov](http://www.faa.gov).
37. FM Approvals - FM Approvals LLC; [www.fmglobal.com](http://www.fmglobal.com).
38. FM Global - FM Global; (Formerly: FMG - FM Global); [www.fmglobal.com](http://www.fmglobal.com).
39. GSA - General Services Administration; [www.gsa.gov](http://www.gsa.gov).
40. HMMA - Hollow Metal Manufacturers Association; (See NAAMM).
41. HUD - Department of Housing and Urban Development; [www.hud.gov](http://www.hud.gov).
42. IAPSC - International Association of Professional Security Consultants; [www.iapsc.org](http://www.iapsc.org).
43. ICBO - International Conference of Building Officials; (See ICC).
44. ICC - International Code Council; [www.iccsafe.org](http://www.iccsafe.org).
45. ICEA - Insulated Cable Engineers Association, Inc.; [www.icea.net](http://www.icea.net).
46. ICRI - International Concrete Repair Institute, Inc.; [www.icri.org](http://www.icri.org).
47. IEEE - Institute of Electrical and Electronics Engineers, Inc. (The); [www.ieee.org](http://www.ieee.org).
48. IES - Illuminating Engineering Society; (Formerly: Illuminating Engineering Society of North America); [www.ies.org](http://www.ies.org).
49. IESNA - Illuminating Engineering Society of North America; (See IES).
50. Intertek - Intertek Group; (Formerly: ETL SEMCO; Intertek Testing Service NA); [www.intertek.com](http://www.intertek.com).

51. ISO - International Organization for Standardization; [www.iso.org](http://www.iso.org).
52. ITU - International Telecommunication Union; [www.itu.int/home](http://www.itu.int/home).
53. LPI - Lightning Protection Institute; [www.lightning.org](http://www.lightning.org).
54. MCA - Metal Construction Association; [www.metalconstruction.org](http://www.metalconstruction.org).
55. MFMA - Metal Framing Manufacturers Association, Inc.; [www.metalframingmfg.org](http://www.metalframingmfg.org).
56. MHIA - Material Handling Industry of America; [www.mhia.org](http://www.mhia.org).
57. MPI - Master Painters Institute; [www.paintinfo.com](http://www.paintinfo.com).
58. NAAMM - National Association of Architectural Metal Manufacturers; [www.naamm.org](http://www.naamm.org).
59. NBI - New Buildings Institute; [www.newbuildings.org](http://www.newbuildings.org).
60. NCAA - National Collegiate Athletic Association (The); [www.ncaa.org](http://www.ncaa.org).
61. NCMA - National Concrete Masonry Association; [www.ncma.org](http://www.ncma.org).
62. NECA - National Electrical Contractors Association; [www.necanet.org](http://www.necanet.org).
63. NEMA - National Electrical Manufacturers Association; [www.nema.org](http://www.nema.org).
64. NETA - InterNational Electrical Testing Association; [www.netaworld.org](http://www.netaworld.org).
65. NFHS - National Federation of State High School Associations; [www.nfhs.org](http://www.nfhs.org).
66. NFPA - National Fire Protection Association; [www.nfpa.org](http://www.nfpa.org).
67. NICET - National Institute for Certification in Engineering Technologies.
68. NRMCA - National Ready Mixed Concrete Association; [www.nrmca.org](http://www.nrmca.org).
69. NSPE - National Society of Professional Engineers; [www.nspe.org](http://www.nspe.org).
70. NSSGA - National Stone, Sand & Gravel Association; [www.nssga.org](http://www.nssga.org).
71. OSHA - Occupational Safety & Health Administration; [www.osha.gov](http://www.osha.gov).
72. PCI - Precast/Prestressed Concrete Institute; [www.pci.org](http://www.pci.org).
73. PLASA - PLASA; (Formerly: ESTA - Entertainment Services and Technology Association); [www.plasa.org](http://www.plasa.org).
74. RoHS – Restriction of Hazardous Substances
75. SCTE - Society of Cable Telecommunications Engineers; [www.scte.org](http://www.scte.org).
76. SIA - Security Industry Association; [www.siaonline.org](http://www.siaonline.org).
77. SMPTE - Society of Motion Picture and Television Engineers; [www.smpte.org](http://www.smpte.org).
78. SPIB - Southern Pine Inspection Bureau; [www.spib.org](http://www.spib.org).
79. SRCC - Solar Rating & Certification Corporation; [www.solar-rating.org](http://www.solar-rating.org).
80. SSINA - Specialty Steel Industry of North America; [www.ssina.com](http://www.ssina.com).
81. SSPC - SSPC: The Society for Protective Coatings; [www.sspc.org](http://www.sspc.org).
82. STI - Steel Tank Institute; [www.steeltank.com](http://www.steeltank.com).
83. TIA - Telecommunications Industry Association (The); (Formerly: TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance); [www.tiaonline.org](http://www.tiaonline.org).
84. TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance; (See TIA).
85. UL - Underwriters Laboratories Inc.; [www.ul.com](http://www.ul.com).
86. UNI - Uni-Bell PVC Pipe Association; [www.uni-bell.org](http://www.uni-bell.org).
87. USGBC - U.S. Green Building Council; [www.usgbc.org](http://www.usgbc.org).
88. USITT - United States Institute for Theatre Technology, Inc.; [www.usitt.org](http://www.usitt.org).
89. WASTEC - Waste Equipment Technology Association; [www.wastec.org](http://www.wastec.org).

## 1.4 DEFINITIONS

- A. Basic Contract definitions are included in the Conditions of the Contract.
  1. Approved: When used to convey Architect's action on Contractor's submittals, applications, and requests, 'approved' is limited to Architect's duties and responsibilities as stated in the Conditions of the Contract.
  2. Concealed: Embedded in masonry or other construction, installed behind wall furring or within double partitions or installed within hung ceilings.

3. Conduit: The inclusion of all fittings, hangers, supports, sleeves, etc.
4. Contractor: As stated herein shall mean Electrical Contractor.
5. Directed: A command or instruction by Architect. Other terms including 'requested,' 'authorized,' 'selected,' 'required,' and 'permitted' have the same meaning as 'directed.'
6. Equal: Equivalent as approved by the Architect or their representative.
7. Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
8. Indicated: Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including 'shown,' 'noted,' 'scheduled,' and 'specified' have the same meaning as 'indicated.'
9. Install: Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.
10. Project Site: Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.
11. Provide: Furnish and install, complete and ready for the intended use.
12. Regulations: Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.
13. Wiring: The inclusion of all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connections, splices, and all other items necessary and/or required in connection with such work.

## 1.5 PERMITS, CODES, AND INSPECTIONS

- A. Contractor shall obtain and pay for all permits and inspections required by laws, ordinances, rules and regulations having jurisdiction for work included under this Contract, and shall submit approval certificates to the Architect.
- B. The electrical installation shall comply fully with
  1. All local, county and state laws, ordinances and regulations having jurisdiction and as applicable to the electrical installations.
  2. All requirements of electric, telephone, and CATV utility companies.
  3. All approved published instructions set forth by equipment manufacturers.
- C. The Electrical installation and all components shall be in compliance with the code and/or standard requirements of the latest revision or state-adopted edition of:
  1. American Society for Testing and Materials (ASTM)
  2. Americans with Disabilities Act (ADA)
  3. FM Global (Factory Mutual) Approval Guide
  4. Institution of Electrical and Electronic Engineers (IEEE)
  5. International Building Code (IBC)
  6. International Fire Code (IFC)
  7. International Energy Conservation Code (IECC)
  8. Legislative Act 235 (1965) - Handicapped
  9. Legislative Act 287 (1974) - Excavation
  10. National Electric Code (NEC)
  11. National Electrical Contractor's Association (NECA)
  12. National Electrical Manufacturer's Association (NEMA)
  13. National Electrical Safety Code (NESC)



- 14. National Fire Protection Association (NFPA)
- 15. National Safety Code
- 16. Occupational Safety and Health Act (OSHA)
- 17. Underwriter's Laboratories, Inc. (UL)

- D. Submit certificates issued by approved authorized agencies to indicate conformance of all work with the above requirements, as well as any additional certificates as may be required for the performance of this contract work.
- E. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Architect prior to execution of the work. The work shall be carried out according to the requirements of such code in accordance with the instruction of the Architect and at no additional cost to the Owner.
- F. Certificate of Inspection: The Contractor shall procure and pay for the Certificate of Inspection from the municipality-approved inspection agency and deliver it to the Architect before final payment is made.

## **1.6 VISITING PREMISES**

- A. The Bidder shall visit the project site before submitting his bid, in order to familiarize himself with existing conditions that may affect his work. It is the Contractor's responsibility to analyze existing conditions. Sufficient allowances shall be provided in the Contractor's bid to cover work, due to existing conditions, that will be required to complete this contract work.
- B. By submission of a bid, the Contractor is attesting that responsible personnel did in fact visit the site during the bidding period and verified all existing pertinent conditions.
- C. Contractor shall verify all measurements and dimensions at the site prior to submitting a bid.

## **1.7 PROJECT DRAWINGS AND SPECIFICATIONS**

- A. Contractor shall carefully examine the Drawings and Specifications of all trades and report all discrepancies to the Architect in writing to obtain corrective action. No departures from the Contract Documents will be made without prior written approval from the Architect.
- B. Questions or disputes regarding the intent or meaning of Contract Documents shall be resolved by the interpretation of the Architect. The Architect's interpretation is final and binding.
- C. The Drawings and Specifications are not intended to define all details, finish materials, and special construction that may be required or necessary. The Contractor shall provide all installations complete and adequate as implied by the project documents.
- D. Drawings are diagrammatic only and do not show exact routes and locations of equipment and associated wiring. The Contractor shall verify the work of all other trades and shall arrange his work to avoid conflicts. In the event of a conflict, the Contractor shall obtain corrective action from the Architect.
- E. All work shall be considered new, unless noted otherwise.
- F. Prior to the submitting of bids, the Contractor shall familiarize himself with all conditions affecting the proposed installation of equipment by all trades that will require electrical connections and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph shall in no way relieve the Contractor of performing all necessary work required for final electrical connections and equipment.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. All materials and equipment for which Underwriter's Laboratories have established standards shall bear a UL label of approval.
- B. When two or more items of same material or equipment are required, they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, wire, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners, and similar items used in work, except as otherwise indicated.
- C. Provide products that are compatible within systems and other connected items.
- D. In all cases where a device, function or item of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.
- E. All listed materials and equipment shown on drawings and/or specified herein, are indicative of complete and whole units and shall be furnished as such.
- F. In certain instances specific manufacturer/model/type and catalog numbers are set out herein or on the drawings for the purpose of indicating required criteria for quality, function, sound level and acceptable physical size. Specifications, performance data, and descriptive data published by the designated manufacturer shall be taken as minimum requirements for the item to be provided.
- G. Comply with manufacturer's printed instructions and recommendations as minimum criteria for the installation of equipment.
- H. Where proprietary names are used, whether or not followed by the words "or as approved", they shall be subject to substitution only as approved by the Architect.
- I. All materials and equipment provided under this Contract shall be completely satisfactory and acceptable in operation, performance and capacity. No approval, either verbal or written, of any drawing, descriptive data or samples of such materials, equipment and/or appurtenances, shall relieve this Contractor of his responsibility to turn over all items in perfect working order at completion of the work.
- J. All material and equipment to be furnished under this contract shall be new and shall conform to the grade, quality and standards specified herein. Items of equipment shall be the latest standard product as advertised in printed catalogues by reputable manufacturers for the purpose intended and shall have replacement parts available.

### **2.2 NAMEPLATE DATA**

- A. Provide factory-installed, permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. All construction under this contract shall be completed in a neat and craftsman-like manner. Work that, in the judgement of the Architect, is not satisfactorily installed shall be removed and replaced to the Architect's satisfaction, at the Contractor's expense.
- B. Throughout construction, all work areas and storage areas shall be kept clean. The Contractor shall keep all items clean of dirt, rust, dust and fingermarks.
- C. The Contractor shall furnish, set, erect, and maintain all scaffolding, aerial equipment and ladders required in the installation of this Contract work.
- D. Install temporary platforms so as to be supported only by the existing steel truss framework.
- E. Painting: Provide in accordance with Division 09 FINISHES Sections and as stated below.
  - 1. Except in Mechanical Rooms, Electrical Rooms, attics, and chase spaces all exposed items provided or installed under this Contract shall be painted.
  - 2. Unless painting is provided by others as elsewhere specified, all painting for items furnished or installed under this Contract shall be the responsibility of this Contractor.
  - 3. Factory-painted equipment cabinets and trim shall not be field-painted except for touching up scratches or damage where necessary to achieve like-new finish. Touching up shall be done after equipment is in its final location.
  - 4. Paint for metal surfaces shall be Rust-o-leum or as approved, one prime coat and two finish coats of color selected by Architect.
  - 5. Items to be painted shall be cleaned and degreased and shall be free of dirt, rust and corrosion prior to application of paint. All paint shall be applied in accordance with all the manufacturer's recommendations (i.e. temperature, dew point, ventilation).
  - 6. All patchwork performed under this Contract shall be painted. Color shall match the color of adjacent walls, ceilings and floors in which patchwork occurs. Area to be painted shall extend a minimum of 24" all around patchwork; however, final limit shall be set by the Architect. Blend new paint work with existing painted surfaces. Where existing finish is stained or varnished woodwork, all damaged or patched surfaces shall be restored to match the existing adjacent surface, as approved. Paint, stain, varnish and method of application shall be as set out in the specifications for General Construction, or as otherwise approved. Except where painting of patchwork is provided by others, as elsewhere specified, all painting of patchwork required under this Contract shall be the responsibility of this Contractor.

### **3.2 COORDINATION**

- A. Sequence of Work
  - 1. Provide in accordance with Division 01 Section SUMMARY.
- B. Outages and Disruptions
  - 1. Continuity of operation of all essential HVAC, plumbing and electrical items, including electrical service, lighting, outlets, power and controls for heating and cooling equipment, auxiliary systems, fire alarm, emergency lighting and power, program, sound, alarms and telephones shall be provided as required for occupancy of the premises during the construction period.

2. Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - a. Notify Owner no fewer than fourteen days in advance of proposed interruption of electric service.
  - b. Indicate method of providing temporary electric service.
  - c. Do not proceed with interruption of electric service without Owner's written permission.
3. Provide temporary wiring and connections to maintain existing systems in service during construction.
4. The schedule and timing of any interruption of water, gas or electrical service or disruption of occupied areas that may affect use of the premises by the Owner and the public, shall be coordinated with the Owner and Architect. Temporary or interim use feeders and facilities shall be provided by the Contractor, as approved and/or directed, to minimize the duration and extent of outages or interruptions.
5. In areas where the construction work will interfere unduly with use of the premises, the Owner may direct that construction work be performed during time periods other than indicated above or on Saturdays, Sundays, or Holidays. Judgment as to whether such undue interference may exist shall rest solely with the Owner. Also, the Owner may require that temporary or interim use feeders and facilities shall be provided by the Contractor as approved and/or directed, to minimize the duration and extent of outages or interruptions.
6. Preparatory work shall be performed as completely as possible in each instance prior to scheduled service outages.
7. Contractor shall be responsible for any and all premium time/overtime required to perform outages and cutovers of services. Coordinate with Owner and Architect.
8. Contractor shall be responsible for any and all premium time/overtime required to complete the work in the various areas within the allotted time, as well as any premium/overtime required to install work through unaffected or remote areas from the work as necessary to maintain continuity of services and occupancy of the existing buildings, as required. Coordinate with Owner and Architect.

C. Demolition

1. Notify the Architect at least 5 days prior to commencing demolition operations.
2. Perform demolition in phases as indicated. Refer to Division 01 for additional requirements.
3. Conditions Affecting Demolition: The following project conditions apply:
  - a. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
  - b. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
  - c. Provide nondestructive removal of materials and equipment for reuse or salvage as indicated on drawings.
  - d. Provide dismantling of electrical materials and equipment made obsolete by these installations.
4. Examination
  - a. Verify field measurements and circuiting arrangements are as shown on Drawings.
  - b. Verify that abandoned wiring and equipment serve only abandoned facilities.
  - c. Drawings are based on casual field observation and existing record documents. Report discrepancies to Owner's representative before disturbing existing installation.
  - d. Beginning of demolition means installer accepts existing conditions.

5. Preparation
  - a. When work must be performed on energized equipment or circuits, use qualified personnel.
6. Demolition and Extension of Existing Electrical Work: Demolish and extend existing electrical work as shown on drawings and as described in this section.
  - a. Remove, relocate, and extend existing installations to accommodate new construction.
  - b. All abandoned wiring shall be disconnected at both ends and removed.
  - c. Remove exposed, abandoned conduit, including abandoned conduit above accessible ceilings. Cut conduit flush with walls and floors, and patch surfaces.
  - d. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
  - e. Repair adjacent construction and finishes damaged during demolition and extension work, as approved.
  - f. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
  - g. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.
  - h. Maintain, restore, and provide electrical service for all receptacles, outlets, lighting fixtures and electrically operated equipment not being demolished. Intercept existing circuit, connect new circuiting into existing circuiting and extend new circuiting back to panelboard or previous "up-stream" device, which is not being removed.
  - i. The Contractor shall maintain the operating condition of the existing Fire Alarm System throughout construction.
7. Disposition of Equipment:
  - a. Unless specified, indicated, or directed otherwise, all material and equipment not intended for reuse on this project that is to be dismantled or removed under this contract, shall become Contractor's property and shall be transported from the premises by the contractor.
  - b. Exceptions: Contractor shall remove and transport the following items without damage to an on-site location as directed, for inspection and possible salvage by Owner:
    - 1) Circuit Breakers and Safety Switches
    - 2) Additional Items as the Owner sees fit during demolition

D. New Work

1. Coordinate electrical equipment installation with other building components.
2. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work.
3. Coordinate connection of electrical services with equipment provided under other sections of the specifications.
4. Coordinate requirements for access panels and doors where electrical items requiring access are concealed behind finished surfaces. Verify all dimensions by field measurements.
5. Coordinate the cutting and patching of building components to accommodate installation of electrical equipment and materials.
6. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.

E. Cooperation and Coordination With Other Trades

1. This Electrical Contractor must cooperate completely and coordinate work with the contractors of other trades providing equipment under this division and other divisions of the specifications. This is particularly important in connection with Divisions 21, 22, and 23 - Mechanical.

F. Space Priority

1. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
  - a. Gravity flow piping systems
  - b. Vent piping systems
  - c. Ceiling recessed lighting fixtures
  - d. Concealed air terminal units, fans
  - e. Air duct systems
  - f. Sprinkler systems piping
  - g. Forced flow piping systems
  - h. Electrical conduit, wiring, control wiring
2. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
3. Change in order of priority is permissible by mutual agreement of all affected trades.
4. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
5. The work of a particular trade shall not obstruct access for installation, operation and maintenance of the Work, materials and equipment of another trade.

### 3.3 SUBSTITUTIONS

- A. Provide in accordance with Division 01 Section SUBSTITUTION PROCEDURES and as stated below.
- B. Where the contractor proposes substitute equipment, contractor to submit complete product data indicating compliance with all requirements of the documents, including performance rating, size and resistance to wear and deterioration equivalent to the specified item at least ten (10) days prior to the bid date. In instances where substituted equipment requires additional material or work beyond that shown or required by the specified item, said additional material or work shall be the responsibility of this Contractor, regardless of the trade involved.

### 3.4 SUBMITTALS

- A. Provide in accordance with Division 01 Section SUBMITTAL PROCEDURES and as stated below.
- B. Submit for approval a complete Material Source of Supply and Subcontractor list for all electrical work required under this project. Shop drawing submittals will not be reviewed until a complete Material Source of Supply and Subcontractor list is received. Submit this listing as a part of the submittal requirement specified in Division 01.
- C. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect will not be processed.

- D. Prepare and submit detailed shop drawings for materials, systems and equipment as listed herein, including locations and sizes of all openings in floor decks, walls and floors.
- E. The work described in any shop drawing submission shall be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing shall include a certification that all related job conditions have been checked and that no conflict exists.
- F. All shop drawings shall be stamped by the Contractor, indicating approval, and space shall be provided for the Engineer's stamp and the Architect's stamp.
- G. All drawings shall be submitted sufficiently in advance of field requirements to allow ample time for checking and resubmittal as may be required. All submittals shall be complete and contain all required and detailed information.
- H. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve the Contractor from responsibility of furnishing all items of proper dimensions, weight, capacities, sizes, quantity and quality as intended by the Contract. Such acceptance shall not relieve Contractor from responsibility for errors, omissions or inadequacies of any sort on submitted data or shop drawings.
- I. Each shop drawing shall contain job title and reference to the applicable drawing and specification article, including the contractor's drawings, specifications and verification of compatibility with the systems involved.
- J. Individual shop drawing submittals shall be provided for each specific material, system or equipment as identified herein. Submittals provided in other than this manner will be return without review.
- K. All nameplate data shall be complete at time of equipment submittals - refer to other sections for identification requirements.
- L. Equipment shall not be ordered or purchased until the shop drawing approval is received.
- M. Shop Drawings shall show conformance with specified electrical characteristics, or Contractor shall assume responsibility for all deviations including all additional costs involved for the deviations.
- N. The following is a list of some important material, equipment and systems that require shop drawing approval, refer to each section of this specification for additional submittal requirements:
  - 1. Low Voltage Electrical Power Cables
  - 2. Grounding and Bonding Equipment
  - 3. Hangers and Supports
  - 4. Raceways and Boxes
  - 5. Fire Alarm Devices
  - 6. Wiring Devices
  - 7. Fuses
  - 8. Enclosed Switches
  - 9. Circuit Breakers

O. Product Options:

1. The product manufacturers listed in each section are either the product the design is based on or a product that the Engineer feels would be an acceptable substitution if that product can meet the intent of the written specifications and the scheduled capacities. The Electrical Contractor is responsible for ensuring that the substituted product complies with the intent of the specifications, the scheduled capacities and the drawings. Substitutions of manufacturers not listed are not permitted unless prior approval is obtained from the Engineer as required by Part 3.3, SUBSTITUTIONS, of this specification section.
2. It will be the responsibility of the Electrical Contractor to pay any and all costs associated with any approved substitutions that impact the architectural layout, structure, electrical system(s), mechanical systems, and/or the plumbing systems, due to an increase in physical dimensions, weight, electrical requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.

### 3.5 QUALITY ASSURANCE AND TESTING

- A. Provide in accordance with Division 01 Section QUALITY REQUIREMENTS.
- B. Provide products that are listed and labeled by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Refer to all Division 26 specification sections for additional testing requirements.

### 3.6 TEMPORARY

- A. Provide in accordance with Division 01 Section TEMPORARY FACILITIES AND CONTROLS and as stated below.
- B. The Electrical Contractor shall provide temporary electric services to the construction areas at locations acceptable to the General Contractor. The service to be provided shall be from the existing electrical system and shall be 3 phase, 4 wire, 208Y/120V, 100 ampere minimum with the necessary distributing facilities. The service shall be installed within fifteen (15) days after written request has been made to the Electrical Contractor, with copies to the Architect and Owner by any contractor requiring such service.
- C. Power consumption shall not disrupt Owner's need for continuous service.
- D. The Contractor shall provide power outlets for construction operations, branch wiring, distribution boxes. Each individual contractor will provide flexible power cords as required.
- E. Power required for tools and operating equipment used for the installation of equipment, that exceeds the power available, shall be temporarily installed and removed by the Contractor requiring it.
- F. Provide wiring and connections for temporary heating equipment required for construction purposes and to prevent building freeze up.
- G. Distribution wiring and equipment/devices used for temporary services shall not be installed as part of the permanent building distribution system.
- H. Permanent distribution wiring and equipment/devices shall not be used for temporary services.



- I. The Contractor shall provide temporary lights and all associated wiring as required by the individual prime contractors.
- J. Contractor to remove all temporary wiring and temporary lighting.

### **3.7 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 Section PRODUCT REQUIREMENTS and as stated below.
- B. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- C. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for distinct identification; adequately packaged and protected to prevent damage during shipment, storage and handling.
- D. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- E. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

### **3.8 CUTTING AND PATCHING**

- A. Provide in accordance with Division 01 Section EXECUTION.

### **3.9 INSTALLATIONS**

- A. Provide in accordance with Division 01 Section EXECUTION and as stated below.
- B. Verify all dimensions by field measurements.
- C. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible.
- D. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
- E. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
- F. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.
- G. Install access panel or doors where units are concealed behind finished surfaces.
- H. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

- I. Obtain written approval of locations of all electrical devices from the Owner and Architect prior to rough-in. The owner reserves the right to move any or all electrical devices prior to rough-in, at no additional cost.
- J. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- K. Obtain approval from the Architect before drilling or cutting structural members.
- L. Holes cut into reinforced concrete beams or in concrete shall not cut reinforcing bars. If the Contractor cuts into any reinforcing bars, stop work and notify the Architect immediately.
- M. Refer to equipment specifications in Divisions 02 through 33 for rough-in requirements for equipment furnished under other contracts.
- N. The installation shall be subject to such revisions as may be necessary to overcome building obstructions.
- O. Provide connections to all electrically operated equipment furnished under other sections and/or divisions of this project specification. Verify all power connections with submitted manufacturer's written recommendations prior to installation and prior to energizing circuit.
- P. Inspect areas and conditions under which electrical connections for equipment that will be installed and notify the Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Contractor.
- Q. Verify that equipment is ready for electrical connection, wiring, and energization.
- R. Install all in-line power control, protection, and disconnection devices furnished by others that are not an integral part of the equipment. These devices shall be located in accordance with the Contractor furnishing the devices and the requirements of the NEC.
- S. Provide for proper rotation of all three phase motors.
- T. Work improperly placed because of Contractor's failure to obtain the above information shall be relocated and reinstalled as directed, without additional costs to the Contract. No charges shall be made in location of equipment without prior written approval.

### **3.10 FINAL CLEANING**

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES.

### **3.11 WARRANTIES**

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES and as stated below.
- B. Refer to individual equipment specifications for additional warranty requirements. If a contradiction exists, the most demanding requirements shall prevail.
- C. Compile and assemble the warranties specified in Division 26 into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

- D. Provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, address, and telephone numbers and procedures for filing a claim and obtaining warranty services.
- E. Submit a single warranty stating that all portions of the work are in accordance with Contract requirements. Warrant all work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. Within 24 hours after notification, correct any deficiencies that occur during the warranty period at no additional cost to Owner, all to the satisfaction of the Owner and Architect. Obtain similar warranties from subcontractors, manufacturers, suppliers and sub-trade specialists.
- F. Any material, equipment or appurtenance whose operation or performance does not comply with the requirements of the Contract Documents or that are damaged prior to acceptance will be held as defective and shall be removed and properly replaced at no additional cost to the Owner.

### **3.12 MAINTENANCE MANUALS**

- A. Provide in accordance with Division 01 Section OPERATION AND MAINTENANCE DATA and as stated below.
- B. Include the following information for equipment items:
  - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
  - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
  - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
  - 4. Servicing instructions and lubrication charts and schedules.
  - 5. Provide a cover sheet for each manual including the project name, Architect's name and contact information, Engineer's name and contact information, and Division 26 contractor's name and contact information.
  - 6. Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
  - 7. Manufacturer's data of each piece of equipment including:
    - a. Installation instructions.
    - b. Drawings and Specifications.
    - c. Parts list, including recommended items to be stocked.
    - d. Complete wiring diagrams.
    - e. Marked or changed prints locating all concealed parts and all variations from the original system design.
    - f. Test and inspection certificates.

### **3.13 RECORD DOCUMENTS**

- A. Provide in accordance with Division 01 Section PROJECT RECORD DOCUMENTS and as stated below.
- B. Indicate installed conditions for the following:
  - 1. Raceway systems, size and location, for both exterior and interior.
  - 2. Locations of control devices.
  - 3. Distribution and branch electrical circuitry.
  - 4. Fuse and circuit breaker size and arrangements.
  - 5. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
  - 6. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

**END OF SECTION 26 0100**

## **SECTION 26 0519 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Copper building wire rated 600 V or less.
  - 2. Metal clad cable, Type MC, rated 600 V or less.
  - 3. Connectors, splices, and terminations rated 600 V and less.

#### **1.3 SUBMITTALS**

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
  - 1. Product Data: Submit manufacturer's data for electrical wires, cables and connectors.

### **PART 2 - PRODUCTS**

#### **2.1 COPPER BUILDING WIRE**

- A. Description: Flexible, insulated, drawn copper current-carrying conductor with an overall insulation layer and jacket, rated 600 V or less.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. Cerro Wire
  - 2. Colonial Wire and Cable Company
  - 3. Encore Wire Corporation
  - 4. General Cable Corporation
  - 5. Nehring Electrical Works Company
  - 6. Okonite Company
  - 7. Service Wire Company
  - 8. Southwire Company

- C. Standards:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  - 2. RoHS compliant.
  - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
- E. Conductor Insulation:
  - 1. Type THHN/THWN-2: Comply with UL 83.

## **2.2 METAL CLAD CABLE, TYPE MC**

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. AFC Cable Systems
  - 2. Encore Wire Corporation
  - 3. Okonite Company
  - 4. Service Wire Company
  - 5. Southwire Company
- C. Standards:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  - 2. Comply with UL 1569.
  - 3. RoHS compliant.
  - 4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Circuits: Single circuit and multi-circuit with color-coded conductors as required.
- E. Conductors for branch circuits, #8AWG and smaller: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors
- F. Ground Conductor: Insulated.
- G. Conductor Insulation: Type THHN/THWN-2: Comply with UL 83.
- H. Armor: Steel, interlocked.
- I. Jacket: PVC applied over armor.

## **2.3 SO MULTICONDUCTOR FLEXIBLE CORD**

- A. Cord Construction: Oil-resistant thermoset insulated type with identified equipment ground conductor, suitable for (extra) hard usage in damp locations.
- B. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

## **2.4 CONNECTORS AND SPLICES**

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use. Use connectors with temperature ratings equal to or greater than those of the wires upon that are used.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. 3M Electrical Products
  - 2. AFC Cable Systems
  - 3. Burndy
  - 4. Hubbell Power Systems
  - 5. Ideal Industries
  - 6. ILSCO
  - 7. NSi Industries
  - 8. O-Z/Gedney
  - 9. TE Connectivity
  - 10. Thomas and Betts Corporation
- C. Jacketed Cable Connectors: For steel jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
  - 1. Material: Match conductor material.
  - 2. Termination: Compression.

## **2.5 COLOR CODING**

- A. Color Coding of Conductors - factory applied the entire length of conductors, provide the following:
  - 1. 208/120V through 240V Conductors:
    - a. Phase A: Black
    - b. Phase B: Red
    - c. Phase C: Blue
    - d. Neutral: White
  - 2. 480/277V and Above Conductors:
    - a. Phase A: Brown
    - b. Phase B: Orange
    - c. Phase C: Yellow
    - d. Neutral: Gray

## **PART 3 - EXECUTION**

### **3.1 DELIVERY, STORAGE AND HANDLING**

- A. Each length, bundle, or reel of wire and cable delivered to job site shall bear manufacturer's name, catalog number and trademark, UL label, type letters, size, length and manufacturing date.
- B. Deliver wire and cable properly packaged in factory fabricated type containers, or wound on NEMA specified type wire and cable reels.
- C. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.
- D. Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

### **3.2 CONDUCTOR MATERIAL APPLICATIONS**

- A. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

### **3.3 CONDUCTOR INSULATION AND MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS**

- A. Branch Circuits:
  - 1. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
  - 2. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway and /or Metal clad cable, Type MC. Provide Type MC cable only for concealed branch circuit wiring in drywall partitions and above accessible ceilings. MC cable shall terminate in a junction box above the finished ceiling of space served by circuiting. All homeruns from branch panelboards shall be routed to space served in EMT conduit, unless otherwise specified. MC cable will not be used as the homerun from space served to panelboard of origin, unless otherwise specified.

### **3.4 INSTALLATION OF CONDUCTORS AND CABLES**

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Provide wire and cable suitable for temperature, conditions and location; and install in compliance with the NEC.
- C. Minimum wire size shall be #12 AWG for all wiring, with the following exceptions:
  - 1. If the distance between the panelboard and the first circuit load is greater than 100 feet, the minimum wire size shall be #10 AWG.
  - 2. Conductors and cables for communications and signal systems shall be as described in respective specification sections and as recommended and approved by manufacturer.



- D. Provide dedicated neutrals for all single-phase branch circuits.
- E. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- F. 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.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Pull conductors simultaneously where more than one is being installed in same raceway.
- I. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- J. Support cables according to Section 26 0529 "Hangers and Supports for Electrical Systems."
- K. MC cable shall be neatly trained and supported clear of ceiling tile and ceiling grid by means of metallic straps or clips. The use of nylon tie wraps to support MC cable from the structure is prohibited. Supports for MC cable shall be independent from supports for other systems (i.e., light fixtures, ceiling grid, mechanical systems) and the supports for the MC cable shall be directly connected to the structure.
- L. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than #10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
- M. Conductor/cable supports for vertical runs shall be provided in top cabinet or pull box of all feeders in accordance with NEC requirements.

### **3.5 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-486B.
- B. Splices:
  - 1. Keep conductor splices to minimum.
  - 2. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  - 3. Splicing of #10 wires and smaller shall be made with Scotchlok or as approved.
  - 4. Splicing of #8 wire and larger shall be made by means of compression type connectors and installed with a proper tool and then insulated to same dielectric value as the original insulation with plastic tape.
  - 5. Splices are not permitted in conductors larger than #10, except where specifically called for.
  - 6. All splicing shall be made in outlet boxes or junction boxes.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

### **3.6 IDENTIFICATION**

- A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."

### **3.7 SLEEVE AND SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS**

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Seals for Electrical Systems".

### **3.8 FIRESTOPPING**

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 26 0544 "Sleeves and Seals for Electrical Systems".

### **3.9 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform each of the following visual and electrical tests:
  - 1. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
  - 2. Test bolted connections for high resistance using one of the following:
    - a. A low-resistance ohmmeter.
    - b. Calibrated torque wrench.
    - c. Thermographic survey.
  - 3. Inspect compression-applied connectors for correct cable match and indentation.
  - 4. Inspect for correct identification.
  - 5. Inspect cable jacket and condition.
  - 6. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
  - 7. Continuity test on each conductor and cable.
  - 8. Uniform resistance of parallel conductors.
- C. Cables will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports to record the following:
  - 1. Procedures used.
  - 2. Results that comply with requirements.
  - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

**END OF SECTION 26 0519**

## **SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

#### **1.3 SUBMITTALS**

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
  - 1. Product data for connectors and connection materials, and grounding fittings.

### **PART 2 - PRODUCTS**

#### **2.1 SYSTEM DESCRIPTION**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Materials: Copper with 98% conductivity.

#### **2.2 MANUFACTURERS**

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. B-Line Systems Inc.
  - 2. Burndy Corporation
  - 3. Erico International
  - 4. ILSCO
  - 5. O-Z/Gedney
  - 6. Thomas and Betts Corporation

## **2.3 CONDUCTORS**

- A. Comply with Division 26 Section 26 0519 " Low Voltage Electrical Power Conductors and Cables."
- B. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, green insulation.
- C. Bare Copper Conductors: Stranded Conductors: ASTM B 8.
- D. Copper Bonding Conductors:
  - 1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 2. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 3. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

## **2.4 CONNECTORS**

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar or compression type, copper or copper alloy, with two wire terminals.
- C. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- D. Bonding Strap: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.
- E. Flexible Jumper Strap: Flexible flat conductor, 480 strands of 30-gauge bare copper wire; 3/4" wide, 9-1/2" long. Protect braid with copper bolt hole ends with holes sized for 3/8" diameter bolts.

## **2.5 ACCESSORIES**

- A. Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type services indicated.

## **PART 3 - EXECUTION**

### **3.1 APPLICATIONS**

- A. Equipment Grounding:
  - 1. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
    - a. Branch circuits.
    - b. Receptacle circuits.
    - c. Single-phase and three-phase motor and appliance branch circuits.
    - d. Metal-clad cable runs.

2. Air Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Install bonding jumper to bond across flexible duct connections to achieve continuity.

### 3.2 INSTALLATION

- A. 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. Terminate insulated equipment grounding conductors with pressure-type grounding lugs.
- B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
  1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment. Use braided type bonding jumpers for flexible bonding and grounding connections.
- C. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
  1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in 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.
  6. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.
  7. Provide connections as follows:
    - a. Equipment Grounding Conductor Terminations: Bolted connectors.

### 3.3 FIELD QUALITY CONTROL

- A. Independent Testing Organization: Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.
- B. Tests and Inspections:
  1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

- C. Grounding system will be considered defective if it does not pass tests and inspections.

**END OF SECTION 26 0526**

## **SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Steel slotted support systems.
  - 2. Aluminum slotted support systems.
  - 3. Nonmetallic slotted support systems.
  - 4. Conduit and cable support devices.
  - 5. Structural steel for fabricated supports and restraints.
  - 6. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
  - 7. Fabricated metal equipment support assemblies.

#### **1.3 SUBMITTALS**

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
  - 1. Product Data: Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions.

### **PART 2 - PRODUCTS**

#### **2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch diameter holes at a maximum of 8 inches o.c. in at least one surface.
  - 1. Manufacturers - subject to compliance with requirements, provide products of one of the following:
    - a. B-Line/Eaton
    - b. Caddy/Pentair
    - c. Flex-Strut, Inc.
    - d. G-Strut/Gregory Industries, Inc.
    - e. Haydon Corporation
    - f. Jet Stream International

- g. Madison Electric Products
  - h. Minerallac Company
  - i. Power-Strut/Atkore
  - j. Superstrut/Thomas & Betts
  - k. Unistrut/Aatkore
  - l. Westrut/Wesanco
2. Standard: Comply with MFMA-4 factory fabricated components for field assembly.
  3. Material for Channel, Fittings, and Accessories: Steel.
  4. Channel Width: Selected for applicable load criteria.
  5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  6. Connect with machine bolts to form rigid supports.
  7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- D. Mounting, Anchoring, and Attachment Components - items for fastening electrical items or their supports to building surfaces include the following:
1. Manufacturers - subject to compliance with requirements, provide products of one of the following:
    - a. B-Line/Eaton
    - b. Empire Industries
    - c. Hilti, Inc.
    - d. MKT Anchoring Systems
    - e. Ramset/ITW
    - f. Rawlplug
    - g. Red Head/ITW
    - h. Simpson Strong-Tie Company
  2. Powder Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
  3. Mechanical Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
  4. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
  5. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
  6. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125/F 3125M, Grade A325 (Grade A325M).
  7. Toggle Bolts: Stainless steel springhead type.
  8. Hanger Rods: Threaded steel.



## **PART 3 - EXECUTION**

### **3.1 APPLICATION**

- A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- B. Boxes, Enclosures and Cabinets:
  - 1. Install surface mounted cabinets with minimum of four anchors.
  - 2. In wet and damp location use steel channel supports to stand cabinets one inch off wall.
  - 3. Use sheet metal channel to bridge studs above and below cabinets recessed in hollow partitions.
- C. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
- D. Use vibration and shock resistant fasteners for attachments to concrete slabs.
- E. Provide vibration and shock resistant fasteners for all moving equipment where the energy of the vibration is of sufficient magnitude to produce perceptible vibration or structure transmitted noise in occupied areas. Isolation equipment shall be selected, installed and adjusted in accordance with manufacturer's recommendations. All equipment and material shall be installed so as to operate without objectionable noise or vibration as determined by Architect and Owner. Should such objectionable noise or vibration be produced and transmitted to occupied portions of the building by apparatus, piping or other parts of this work, any necessary changes as approved shall be made by the Contractor.

### **3.2 SUPPORT INSTALLATION**

- A. Unless otherwise indicated, fasten all electrical items and their supporting hardware securely to the building structure.
- B. Coordinate with the building structural system and other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Raceway Support Methods:
  - 1. In addition to methods described in NECA 1, conduit may be supported by openings through structure members, according to NFPA 70.
  - 2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.
  - 3. Support individual horizontal raceways by separate pipe hangers.
  - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
  - 5. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways.
  - 6. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
  - 7. Secure raceways to steel slotted supports with spring nuts using spring friction action for retention in support channel.

8. Spring steel fasteners may be used only for 3/4" raceways above suspended ceilings. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
  9. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals. Install simultaneously with installation of conductors.
- D. 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 pounds.
- E. 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. Instead of expansion anchors, powder actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
  5. To Steel: Beam clamps (MSS SP-58, 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.
- F. Install hangers, supports, clamps and attachments to support raceways, boxes, enclosures and cabinets properly from building structure.
- G. Install supports with spacings indicated and in compliance with NEC requirements.
- H. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
- I. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.
- J. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures.
- K. The use of clips or clip-on type supports is not acceptable.

### **3.3 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. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

## **END OF SECTION 26 0529**

## **SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 08 Section "OPENINGS" for Access Doors.

#### **1.2 SUMMARY**

- A. This Section includes raceways for electrical wiring. Types of raceways in this section include the following:
  - 1. Conduits and fittings
  - 2. Boxes, enclosures, and cabinets
  - 3. Access doors

#### **1.3 SUBMITTALS**

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
  - 1. Product Data - submit manufacturer's data for the following:
    - a. Conduits and fittings
    - b. Boxes, enclosures, and cabinets
    - c. Access doors

### **PART 2 - PRODUCTS**

#### **2.1 METAL CONDUITS AND FITTINGS**

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. AFC Cable Systems/Konkore
  - 2. Allied Tube & Conduit
  - 3. Anamet Electrical, Inc.
  - 4. Arlington
  - 5. Bridgeport
  - 6. Calconduit
  - 7. Crouse-Hinds/Eaton
  - 8. Electri-Flex
  - 9. Flexotek
  - 10. KonKore

11. Korkap
12. NEC, Inc.
13. O-Z/Gedney
14. Nucor (Republic Conduit)
15. Patriot Aluminum Products
16. Perma-Cote
17. Phoenix
18. Picoma Industries, Inc.
19. Plasti-Bond
20. RACO/Hubbell
21. Southwire Company
22. Teddico Electrical Products
23. Thomas & Betts/ABB
24. Topaz Electric
25. Western Tube
26. Wheatland Tube

B. Metallic Conduit: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. Electrical Metallic Tubing (EMT): Comply with ANSI C80.3 and UL 797.
2. Flexible Metal Conduit (FMC): Comply with UL 1; zinc-coated steel.
3. Liquid-tight Flexible Metal Conduit (LFMC): Flexible steel conduit with PVC jacket and complying with UL 360.
4. Rigid Metal Conduit (RMC): Comply with ANSI C80.1 and UL 6.

C. Metal Fittings: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Comply with NEMA FB 1 and UL 514B.

1. Fittings for EMT: Steel, compression type.
2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
3. Fittings for FMC:
  - a. Straight Terminal Connectors: One piece body, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.
  - b. 45° or 90° Terminal Angle Connectors: Two-piece body construction with removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.
4. Fittings for LFMC: Cadmium plated, steel fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated, or non-insulated throat.
5. Fittings for RMC: Threaded.
6. Fittings for IMC: Threaded.
7. Fittings for PVC-Coated Conduit: PVC coated, minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
8. Joint Compound for RMC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.2 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers - subject to compliance with requirements, provide products of one of the following:

1. Adalet
2. Appleton Electric/Emerson
3. Cope
4. Crouse-Hinds/Eaton
5. FSR Inc.
6. Hoffman/Pentair
7. Kraloy
8. Milbank Manufacturing
9. OZ/Gedney
10. RACO/Hubbell
11. Spring City Electrical Manufacturing
12. Steel City/Thomas & Betts Company
13. Topaz Electric
14. Wiegmann/Hubbell

B. Device Boxes:

1. Provide size as required by drawings, minimum 2-1/8 inches deep. Boxes shall be one-piece type, gangable boxes are prohibited.
2. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
3. Cast Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
4. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

C. Pull and Junction Boxes:

1. Sheet Metal Pull and Junction Boxes: NEMA OS 1.
2. Cast Metal Pull and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
3. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.

D. Accessories:

1. Provide accessories as required for each installation.
2. Provide box supports, mounting ears and brackets, box extension rings, fixture studs, cable clamps and metal straps for supporting boxes, that are compatible with boxes being used to fulfill installation requirements for individual wiring situations.
3. Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes to suit respective installation requirements and applications.
4. Provide stainless steel screws and hardware unless noted otherwise.

## 2.3 ACCESS DOORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
1. Babcock-Davis
  2. JL Industries, Inc.
  3. Karp Associates, Inc.
  4. Milcor
  5. Nystrom, Inc.
- B. General:
1. Provide access door and frame assemblies manufactured as integral units ready for installation.
  2. Provide factory fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
  3. Refer to Section 08 3113 'Access Doors and Frames' for additional requirements.
- C. Materials:
1. Face of door flush with frame, with exposed flange and concealed hinge.
  2. Uncoated Steel Sheet for Door: Nominal 0.060 inch, 16 gauge, factory finished.
  3. Frame Material: Same material and thickness as door.
  4. Latch and Lock: Cam latch, screwdriver operated
  5. Fire Rated Units:
    - a. Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
    - b. Fire-Resistance Rating: Not less than that of adjacent construction.
    - c. Provide with UL label.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Raceways:
1. Minimum Raceway Size: 3/4-inch trade size.
  2. Indoor Installations: Apply raceway products as specified below unless otherwise indicated:
    - a. Exposed: EMT.
    - b. Concealed in Ceilings and Interior Walls and Partitions: EMT or MC cable. Provide Type MC cable only for concealed branch circuit wiring in drywall partitions and above accessible ceilings. MC cable shall terminate in a junction box above the finished ceiling of space served by circuiting. All homeruns from branch panelboards shall be routed to space served in EMT conduit, unless otherwise specified. MC cable will not be used as the homerun from space served to panelboard of origin, unless otherwise specified.
    - c. Concealed in masonry walls: PVC. Transition PVC conduit to metal conduit prior to exiting masonry wall using female adapter on PVC conduit for connection to male adapter on metal conduit. This shall provide one continuous raceway into masonry wall.
    - d. Final connection to recessed and semi-recessed lighting fixtures, not to exceed 72": FMC.
    - e. Damp or Wet Locations: RMC.

- f. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
- 3. Outdoor Installations - apply raceway products as specified below unless otherwise indicated:
  - a. Exposed Conduit: RMC.
  - b. Concealed Conduit, Aboveground: RMC.
  - c. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- 4. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - a. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
  - b. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
  - c. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  - d. Damp or Wet Locations: Watertight fittings.
- B. Boxes, Enclosures, and Cabinets
  - 1. Provide boxes, enclosures and cabinets and associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements, unless drawings indicate a more stringent requirement:
    - a. Interior Dry Locations: Sheet steel, NEMA type 1.
    - b. Locations Exposed to Weather or Dampness: Cast metal, NEMA type 3R, with threaded hub(s) and gasketed weatherproof cover.
- C. Access Doors
  - 1. Where installed in a fire-rated wall or ceiling, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.

## 3.2 INSTALLATION

- A. General:
  - 1. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems".
  - 2. Complete installation of raceways, boxes, enclosures, and cabinets before starting conductor installation.
  - 3. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
  - 4. Support conduit within 12 inches of boxes, enclosures or cabinets to which attached and within 12 inches of change of direction.
  - 5. Do not install aluminum boxes or fittings in contact with concrete or earth.
  - 6. Install raceways square to boxes, enclosures and cabinets and terminate with locknuts. Install locknuts hand tight plus 1/4 turn more.

7. Do not rely on locknuts to penetrate nonconductive coatings on boxes, enclosures and cabinets. Remove coatings in the locknut area prior to assembling conduit to ensure a continuous ground path.
8. Prevent foreign matter from entering raceways, boxes, enclosures and cabinets by using temporary closure protection.
9. Upon completion of installation of raceways, boxes, enclosures and cabinets, inspect interiors and clear all blockages and remove burrs, dirt, and construction debris.

B. Raceways:

1. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed.
2. Make bends in raceway using either large-radius preformed elbows or field bending. Use only equipment specifically designed for material and size involved. Make bends and offsets so the inside diameter is not effectively reduced.
3. Run parallel raceways together.
4. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
5. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-pound tensile strength. Leave at least 12 inches of slack at each end of pull wire.
6. Do not run raceways exposed on floors.
7. Do not run raceways exposed on roofs.
8. Where raceways terminate at locations subject to moisture, provide insulating bushings to protect conductors.
9. Where terminations are subject to vibration, use bonding bushings or wedges to ensure electrical continuity.
10. Indoor Raceways:
  - a. Conceal conduit within finished walls, ceilings, and floors except in equipment rooms and attics/crawl spaces, unless otherwise indicated.
  - b. Do not fasten conduits onto the bottom side of a metal deck roof.
  - c. 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.
  - d. Install conduits parallel or perpendicular to building lines.
  - e. Where a ceiling is scheduled to be exposed to structure, all conduit shall be secure to structure to provide a clean, organized appearance. Where routed between structural elements, install conduit as high as practical.
  - f. Where conduit is installed concealed in masonry walls, transition PVC conduit within masonry wall to otherwise-specified interior or exterior raceway.
  - g. Terminations:
    - 1) Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box.
    - 2) Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.
    - 3) Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder.
    - 4) Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.



h. Expansion Joint Fittings:

- 1) Install in each run of EMT conduit that is located where environmental temperature change may exceed 100°F and that has straight-run length that exceeds 100 feet.
- 2) Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
  - a) Indoor Spaces Connected with Outdoors without Physical Separation: 125°F temperature change.
  - b) Attics: 135°F temperature change.
- 3) Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per degree F of temperature change for metal conduits.
- 4) Install expansion fittings at all locations where conduits cross building or structure expansion joints.
- 5) Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

11. Raceway Sealants:

- a. Install raceway sealing fittings at accessible locations according to NFPA 70 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 according to NFPA 70.
- b. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
  - 1) Conduit extending from interior to exterior of building.
  - 2) Where otherwise required by NFPA 70.

12. 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.

C. Boxes, Enclosures and Cabinets:

1. Locations shown on Contract Drawings are approximate unless dimensioned.
2. Mount at heights indicated on Drawings. If mounting heights are not individually indicated, give priority to ADA requirements. Install with height measured to top of box unless otherwise indicated.
3. Provide support of junction and pull boxes from building structure. Do not support boxes by conduits.
4. Position recessed boxes, enclosures and cabinets to allow for surface finish thickness.
5. Mount boxes, enclosures and cabinets with fronts straight and plumb.
6. Install surface-mounted cabinets with minimum of four anchors.
7. Locate and install to allow access. Where installation is otherwise inaccessible, coordinate locations and sizes and provide required access doors.
8. Coordinate masonry cutting to achieve neat openings.
9. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
10. Locate so that cover or plate will not span different building finishes.

11. Do not install boxes back-to-back in walls. Provide minimum 6-inch separation. Provide minimum 24-inch separation in acoustic-rated walls.
12. Coordinate mounting heights and locations of wall outlets mounted where counters, benches, and backsplashes are to be installed. Install outlets 6" above tops of counters and benches.
13. Coordinate mounting heights and locations of wall outlets where wall-mounted heating units are to be installed.
14. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
15. Mount outlet boxes for switches and receptacles with the long axis vertical unless noted otherwise. Three or more gang boxes shall be mounted with the long axis horizontal.
16. Electrically ground metallic boxes, enclosures and cabinets.
17. Where wiring to an item that includes a grounding conductor, provide a grounding terminal in the interior of the box, enclosure or cabinet.
18. Existing Outlet Boxes: Where extension rings are required to be installed, drill new mounting holes in the rings to align with the mounting holes on the existing boxes where existing holes are not aligned.

D. Installation of Access Doors:

1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
2. Adjust hardware and panels after installation for proper operation.

E. Sleeve and Sleeve Seal Installation for Electrical Penetrations:

1. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Seals for Electrical Systems".
2. Install firestopping at penetrations of fire rated floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Seals for Electrical Systems".

### 3.3 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to painted finishes using matching corrosion inhibiting touch-up coating recommended by the manufacturer.

### END OF SECTION 26 0533

## **SECTION 26 0544 - SLEEVES AND SEALS FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 07 THERMAL AND MOISTURE PROTECTION Sections.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors
  - 2. Sleeve seal systems and fittings
  - 3. Grout
  - 4. Sealants
  - 5. Firestopping

#### **1.3 SUBMITTALS**

- A. Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
  - 1. Product data for the following products:
    - a. Sealants
    - b. Firestopping

### **PART 2 - PRODUCTS**

#### **2.1 SLEEVES**

- A. Wall Sleeves:
  - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
  - 2. Cast iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw fastening the sleeve to the board.

## **2.2 SLEEVE SEAL SYSTEMS AND FITTINGS**

- A. Description: Provide modular mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates that cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
- B. Material:
  - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Stainless steel.
  - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.
- C. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. Advance Products and Systems Inc.
  - 2. Calpico
  - 3. GPT Industries
  - 4. MetraFlex
  - 5. Proco Products, Inc.

## **2.3 GROUT**

- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## **2.4 SILICONE SEALANTS**

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
  - 2. Color: As selected by the Architect from manufacturer's standard colors.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.
- C. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. 3M
  - 2. Adfast
  - 3. Dow Corning Corporation

4. GE Construction Sealants
5. Pecora Corporation
6. Rectorseal
7. Sika Corporation
8. Soudal USA
9. Tremco, Inc.

## 2.5 FIRESTOPPING

### A. General:

1. Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.
2. Equipment used shall be in accordance with the firestop manufacturer's written installation instructions.
3. Color: Red.

### B. Performance Requirements

1. Fire Test Response Characteristics:
  - a. Perform penetration firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
  - b. Test per testing standards referenced in "Penetration Firestopping Systems" article. Provide rated systems complying with the following requirements:
  - c. Penetration firestopping systems shall bear classification marking of a qualified testing agency.
    - 1) UL in its "Fire Resistance Directory."
    - 2) FM Global in its "Building Materials Approval Guide."

### C. Penetration Firestopping Systems

1. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.
2. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
  - a. F-Rating: Not less than the fire-resistance rating of constructions penetrated.
3. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
  - a. F-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated.
  - b. T-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.
  - c. W-Rating: Provide penetration firestopping systems showing no evidence of water leakage when tested according to UL 1479.

4. Penetrations in Smoke Barriers: Penetration firestopping systems with ratings determined per UL 1479, based on testing at a positive pressure differential of 0.30-inch wg.
  - a. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at and no more than 50-cfm cumulative total for any 100 sq. ft. at both ambient and elevated temperatures.
5. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, per ASTM E 84.
6. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.
  - a. Permanent forming/damming/backing materials.
  - b. Substrate primers.
  - c. Collars.
  - d. Steel sleeves.

#### D. Fill Materials

1. Cast-in-Place Firestop Devices: Factory assembled devices for use in cast-in-place concrete floors and consisting of an outer sleeve lined with an intumescent strip, a flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.
2. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.
3. Firestop Devices: Factory assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
4. Intumescent Composite Sheets: Rigid panels consisting of aluminum foil faced intumescent elastomeric sheet bonded to galvanized steel sheet.
5. Intumescent Putties: Non-hardening, water-resistant, intumescent putties containing no solvents or inorganic fibers.
6. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.
7. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers and lightweight aggregate formulated for mixing with water at Project site to form a non-shrinking, homogeneous mortar.
8. Pillows/Bags: Reusable heat expanding pillows/bags consisting of glass fiber cloth cases filled with a combination of mineral fiber, water insoluble expansion agents, and fire-retardant additives. Where exposed, cover openings with steel reinforcing wire mesh to protect pillows/bags from being easily removed.
9. Silicone Foams: Multicomponent, silicone based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.
10. Silicone Sealants: Single-component, silicone based, neutral curing elastomeric sealants.

#### E. Mixing

1. Penetration Firestopping Materials: For those products requiring mixing before application, comply with penetration firestopping system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

F. Manufacturers - subject to compliance with requirements, provide products of one of the following:

1. 3M
2. A/D Fire Protection Systems
3. Emerson/Nelson
4. Hilti
5. Nuco Inc.
6. PFP Partners
7. RectorSeal
8. Specified Technologies Inc.
9. Tremco, Inc.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Contractor shall provide sleeves where raceways pass through walls, floors, and ceilings.
- B. Where piping or raceways pass through waterproofed floors or walls, design of sleeves shall be such that waterproofing can be flashed into and around the sleeves.
- C. Where items pass through roofs, coordinate the installation with the roofing installer and provide an approved penetration to maintain the roof warranty.

### **3.2 SLEEVE INSTALLATION**

- A. Sleeves for Conduits Penetrating Above-Grade Concrete and Masonry Unit Floors and Walls:
  1. Interior Penetrations of Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall/floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  2. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
  3. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during construction of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  4. Install sleeves for floor penetrations. Extend sleeves installed in floors 6 inches above finished floor level. Install sleeves during construction of floors.
- B. Sleeves for Conduits Penetrating Gypsum Board Assemblies:
  1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- C. Roof Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

- D. Aboveground, Exterior Wall Penetrations: Seal penetrations using stainless steel pipe 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.
- E. Underground, Exterior Wall and Floor Penetrations: Install cast iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

### **3.3 SLEEVE SEAL SYSTEMS AND FITTINGS INSTALLATION**

- A. Provide sleeve seal system for below-grade sleeves through exterior walls.
- B. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- C. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- D. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates in accordance with manufacturer's recommended values to ensure that sealing grommets expand to make watertight seal.
- E. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.
- F. Secure nailing flanges to concrete forms.
- G. Using grout, seal the space around outside of sleeve seal fittings.

### **3.4 SEALANTS**

- A. General:
  - 1. Comply with joint sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
  - 2. Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- B. Preparation:
  - 1. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
    - a. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
    - b. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air.



- c. Remove laitance and form-release agents from concrete.
  - d. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
- 2. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- 3. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.
- C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
  - 1. Do not leave gaps between ends of sealant backings.
  - 2. Do not stretch, twist, puncture, or tear sealant backings.
  - 3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
  - 1. Place sealants so they directly contact and fully wet joint substrates.
  - 2. Completely fill recesses in each joint configuration.
  - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
  - 1. Remove excess sealant from surfaces adjacent to joints.
  - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- G. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.
- H. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

### 3.5 FIRESTOPPING

#### A. General:

1. Where conduits, conduit sleeves, wireways and other electrical raceways or cables pass through fire partitions, fire walls, fire floors, or smoke walls, provide a fire or smoke stopping that provides an effective barrier against the spread of fire, smoke or gases.
2. Provide firestopping with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.
3. Install materials in accordance with printed instructions of the UL Fire Resistance Directory and per manufacturer's published instructions.
4. All cables that are installed in conduit sleeves or in wireways through fire or smoke floors or partitions shall be provided with an equally rated re-enterable UL listed fire and smoke rated silicone RTV foam in the opening.
5. Keep areas of work accessible until inspection by applicable code authorities.

#### B. Preparation:

1. Surface Cleaning: Before installing penetration firestopping systems, clean out openings immediately to comply with manufacturer's written instructions and with the following requirements:
  - a. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of penetration firestopping materials.
  - b. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping materials. Remove loose particles remaining from cleaning operation.
  - c. Remove laitance and form-release agents from concrete.

#### C. Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.

#### D. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.

#### E. Install fill materials by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

#### F. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping system manufacturers and that do not damage materials in which openings occur.

- G. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping material and install new materials to produce systems complying with specified requirements.

**END OF SECTION 26 0544**

## **SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Cable/Conductor Identification Bands
  - 2. Laminated Acrylic or Melamine Plastic Labels
  - 3. Self-Adhesive Labels

#### **1.3 SUBMITTALS**

- A. Product Data for each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

### **PART 2 - PRODUCTS**

#### **2.1 ELECTRICAL IDENTIFICATION PRODUCTS**

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  - 1. Brady Corporation
  - 2. Champion America
  - 3. Emedco
  - 4. Grafoplast
  - 5. Hellerman Tyton
  - 6. Ideal Industries
  - 7. LEM Products, Inc.
  - 8. Marketing Services, Inc.
  - 9. Panduit

- B. General: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.
- C. Cable/Conductor Identification Bands: Provide manufacturer's standard aluminum wrap-around cable/conductor markers, of size required for proper application with stamped or embossed legend, and numbered to show circuit identification.
- D. Laminated Acrylic or Melamine Plastic Labels
  - 1. Engraved with black letters on white face, unless noted otherwise.
  - 2. Thickness:
    - a. For signs up to 20 sq. in. minimum 1/16 inch thick.
    - b. For signs larger than 20 sq. inch, 1/8 inch thick.
  - 3. Fasteners for Laminated Acrylic or Melamine Plastic Labels:
    - a. Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers. Where screws cannot or should not penetrate substrate, provide contact type permanent adhesive.
- E. Self-Adhesive Labels
  - 1. Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
  - 2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. Install identifying devices before installing acoustical ceilings and similar concealment.
- B. Verify identity of each item before installing identification products.
- C. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

### 3.2 APPLICATION AND INSTALLATION

- A. Accessible Fittings for Raceways: Using permanent marker, identify the covers of each junction and pull box with the panelboard and circuit number(s) of installed conductors.
- B. Cable/Conductor Identification Bands: Apply cable/conductor identification bands indicating circuit number on each cable/conductor in each panelboard.
- C. Labels
  - 1. General
    - a. Attach labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
    - b. Before applying self-adhesive electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.
    - c. Apply labels to exterior of door or cover. In finished areas, install labels to inside face of doors.
    - d. Provide labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
    - e. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.
  - 2. Equipment Identification Labels: Provide laminated acrylic or melamine plastic equipment identification labels for each device in the following categories of electrical equipment. Text shall match terminology and numbering of the Contract Documents and shop drawings.
    - a. Disconnect switches
    - b. Circuit breakers in distribution panel(s)

**END OF SECTION 26 0553**

## **SECTION 26 1900 - FIRE ALARM DEVICES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 23 Heating Ventilating and Air Conditioning Monitoring & Control (HVAC).

#### **1.2 SUMMARY**

- A. This specification describes an addressable fire detection and alarm signaling system.
- B. This Section includes system components including the following:
  - 1. Duct smoke detectors.
  - 2. Carbon monoxide detectors.
- C. Provide complete fire alarm system including all required hardware, raceways, interconnecting wiring and software to accomplish the requirements of this specification and the contract drawings and in accordance with the manufacturer's instructions, whether or not specifically itemized herein.

#### **1.3 ABBREVIATIONS**

- A. NAC: Notification Appliance Circuit

#### **1.4 DEFINITIONS**

- A. Alarm Initiating Device: A manual station, smoke detector, heat detector, flame detector, or sprinkler water flow switch.
- B. Alarm Signal: Signifies a state of emergency requiring immediate action. Pertains to signals such as the operation of a manual station and the operation of a sprinkler system flow switch.
- C. Supervisory Signal: Indicates need for action regarding fire suppression or other protective system.
- D. Trouble Signal: Indicates that a fault, such as an open circuit or ground, has occurred in the system.

#### **1.5 SUBMITTALS**

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

- B. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Complete manufacturer's catalog data including supervisory power usage, alarm power usage, physical dimensions, and finish and mounting requirements.
- C. Power calculations. Battery capacity calculations. Battery size shall be a minimum of 125% of the calculated requirement. Provide the following supporting information:
  - 1. Supervisory power requirements for all equipment.
  - 2. Alarm power requirements for all equipment.
  - 3. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst-case condition plus 25% spare capacity.
  - 4. Voltage drop calculations for wiring runs demonstrating worst-case condition.
  - 5. NAC circuit design shall incorporate a 25% spare capacity.
  - 6. Addressable SLC circuit design shall incorporate 25% spare capacity.
  - 7. IDC circuit design shall allow only a single initiating device installed on each IDC so that it is uniquely identified on the system.
- D. Submit manufacturer's requirements for testing Signaling Line Circuits and device addresses prior to connecting to control panel. At a minimum the following tests shall be required; device address, the usage (Alarm, Supervisory etc.), environmental compensation, temperature ratings for thermal detectors and smoke detector sensitivities. This requirement shall need approval before any wiring is connected to the control panel.
- E. Fire Alarm Permit Drawings: This electrical contractor shall also submit all documents, drawings, calculations, etc. identified in Section 907 of the IBC to the Local Authority Having Jurisdiction (AHJ) for "Approval" prior to commencing work. All costs for Permits and Inspections by the AHJ shall be by the Electrical Contractor.
- F. Qualification Data: For qualified Installer, Applicator, manufacturer, fabricator, professional engineer, testing agency, and factory-authorized service representative.

## **1.6 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in manufacture of devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installers:
  - 1. Provide the services of a factory trained and certified representative or technician, experienced in the installation and operation of the type of system provided. The representative shall be licensed in the State if required by law.
  - 2. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the owner's personnel in the system operation and maintenance.
  - 3. The contractor shall employ on staff a minimum of one NICET level II technician or a professional engineer, registered in the State of the installation.
  - 4. Contractors unable to comply with the provisions of Qualification of Installers shall present proof of engaging the services of a subcontractor qualified to furnish the required services.



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

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver products to project site in original, unopened packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, and shelf life if applicable.
- B. Store materials inside, under cover, above ground, and kept dry and protected from physical damage until ready for use. Remove from site and discard wet or damaged materials.

## **1.8 WARRANTY**

- A. Manufacturer's standard form in which manufacturer agrees to repair or replace fire alarm equipment that fail(s) in materials or workmanship within 1 year from date of Substantial Completion.

# **PART 2 - PRODUCTS**

## **2.1 MANUFACTURERS**

- A. Manufacturers: subject to compliance with requirements, provide products of one of the following:
  - 1. Siemens - to match existing system.

## **2.2 GENERAL**

- A. All equipment furnished shall be new and the latest state of the art products of a single manufacturer.
- B. All equipment shall be sourced from a single supplier for fire alarm equipment, engineering, programming, inspection and tests, and shall be capable of providing a "UL Listing Certificate" for the complete system.
- C. System Description
  - 1. Components shall be compatible with, and operate as an extension of, existing system (if shown as an expansion of an existing system on the contract drawings). Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
  - 2. All components provided shall be listed for use with the selected system.
  - 3. All electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## **2.3 SYSTEM SMOKE DETECTORS**

- A. General Requirements for System Smoke Detectors:
  - 1. Comply with UL 268 7<sup>th</sup> Edition; operating at 24-V dc, nominal.
  - 2. Detectors shall be two-wire type.
  - 3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5. Integral Visual-Indicating Light: LED type, indicating detector is operational and power-on status.
6. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire alarm control unit.
  - a. Multiple levels of detection sensitivity for each sensor.
  - b. Sensitivity levels based on time of day.

B. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).
3. Each sensor shall have multiple levels of detection sensitivity.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.
6. Provide a remote indicator lamp for all air sampling smoke detectors and install in an approved, accessible location. Provide a custom label for each remote indicator lamp (ie: AHU-1 Supply Duct Detector).

## 2.4 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire alarm system.
8. Test button simulates an alarm condition.

## 2.5 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- C. Control Module: Operate notification devices.

## **2.6 FIRE ALARM WIRE AND CABLE**

- A. Class A (style D & Z) Wiring: Circuits arranged and electrically supervised so a single break or single ground fault condition will be indicated by a trouble signal at the FACP and the circuit will continue to be capable of operation for its intended service in the faulted condition no matter where the break or ground fault condition occurs.
- B. The type and quantity of conductors shall be as required by the equipment manufacturer.
- C. Provide Fire Alarm MC Cable, fully plenum rated, with galvanized interlocking steel strip and factory-applied red finish in accordance with specification Section 26 0519 "Low Voltage Electrical Power Conductors and Cables".
- D. All splices shall be made using solderless connectors. All connectors shall be installed in conformance with the manufacturer's recommendations.
- E. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.

## **PART 3 - EXECUTION**

### **3.1 EXISTING FIRE ALARM SYSTEM**

- A. When connecting to existing-to-remain equipment:
  - 1. Verify that existing fire alarm system is operational before making changes or connections.
  - 2. Connect new equipment to existing control panel in existing part of the building.
  - 3. Expand, modify, and supplement existing equipment as necessary to extend existing functions to the new points.
  - 4. New components shall be capable of merging with existing configuration without degrading the performance of either system.

### **3.2 INSTALLATION**

- A. General
  - 1. Inspect each device for damage prior to installation. Replace damaged devices.
  - 2. Install system in accordance with NFPA guidelines.
  - 3. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
  - 4. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
  - 5. Examine rough-ins for electrical connections to verify actual locations of connections before installation.

6. Proceed with installation only after unsatisfactory conditions have been corrected.
7. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Equipment

1. Detectors:

- a. Install detectors indicated to be ceiling mounted not less than 4 inches from a side wall to the near edge.
- b. On flat ceilings, install detectors not over 30 feet apart in any direction.
- c. Install detectors no closer than 5 feet from air-supply diffuser or return-air opening.
- d. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

2. Duct Smoke Detectors:

- a. Furnish all duct or unit mounted smoke detectors, and provide power wiring (if required) and fire alarm control wiring to these smoke detectors. Detectors shall be provided with alarm contacts for use by the DDC system.
- b. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
- c. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

3. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector that is not readily visible from normal viewing position.

C. Wiring

1. Where routed concealed, provide fire alarm type metal-clad cable.
2. Where routed exposed, install wiring in metal raceway with factory applied red finish.
3. The exact wiring arrangement shall be in accordance with the fire alarm equipment manufacturer's requirements.
4. Wiring within Enclosures: Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. Make all connections with approved crimp-on terminal spade lugs, pressure type terminal blocks, or plug connectors. Wiring shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.
5. Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where any circuit tap is made.
6. Mount end-of-line device box with last device or separate box adjacent to last device in circuit.

- D. Connections: Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.

### **3.3 IDENTIFICATION**

- A. The Electrical Contractor shall provide a Label for each addressable device identifying the device's System Address (i.e.: 01-065).
- B. Color Coding: Color code all fire alarm conductors differently from the normal building power wiring. Provide one color code for alarm circuits wiring and a different color code for supervisory circuits. Provide a color code for audible alarm indicating circuits different from alarm initiating circuits. Use different colors for visual alarm indicating devices. Paint fire alarm system junction boxes and covers red.
- C. Each conductor shall be identified as shown on the drawings with wire markers at every splice and terminal point. Attach permanent wire markers within 2 inches of the wire termination. Marker legends shall be visible.

### **3.4 PROGRAMMING**

- A. The Contractor and Manufacturer's Representative shall meet with the Owner and review the requirements for device and location identifications prior to entering any script files. All script files shall be in accordance with the Owner's requirements.

### **3.5 FIELD QUALITY CONTROL**

- A. Field tests shall be witnessed by the AHJ.
- B. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Pretesting: Upon completing installation of the system, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- D. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable. The letter shall include the names and titles of the witnesses to the preliminary tests.
- E. Final Test Notice: Provide 10 days' minimum notice in writing when the system is ready for final acceptance testing.
  - 1. Minimum System Test: Test the system in accordance with the procedures outlined in NFPA 72. Testing specified shall be performed by the installing contractor, the distributor's technician and the building inspector. Minimum required tests are as follows:
  - 2. Verify the absence of unwanted voltages between circuit conductors and ground.
  - 3. Megger test all conductors other than those intentionally and permanently grounded with electronic components disconnected. Test for resistance to ground. Report readings less than 1-megohm for evaluation.
  - 4. Test all conductors for short circuits utilizing an insulation testing device.
  - 5. Verify the control unit is in the normal condition as detailed in the manufacturer's operating and maintenance manual.

6. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and indicating devices. Proper signal transmission in accordance with class of wiring used shall be observed.
  7. Test each initiating and indicating device for alarm operating and proper response at the control unit. Test smoke detectors with actual products of combustion.
  8. Test the system for all specified functions in accordance with the manufacturer's operating and maintenance manual. Systematically initiate specified functional performance items at each station including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.
- F. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests.
1. Provide both a "System Record of Completion" and the "System Record of Inspection and Testing" as outlined in NFPA 72. Each shall be fully executed by the manufacturer's representative and the AHJ.
- H. Tag all equipment and stations and other components at which tests have been satisfactorily completed. Place tags upon completion of tests.

### **3.6 DEMONSTRATION AND TRAINING**

- A. Provide the services of a factory authorized service representative to demonstrate and train Owner's maintenance personnel as specified below.
1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 4 hours of training.
  2. Schedule training with the Owner at least seven days in advance.

**END OF SECTION 26 1900**

## **SECTION 26 2726 - WIRING DEVICES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems that are intended to carry, but not utilize, electric energy.
- B. This Section includes the following:
  - 1. Receptacles:
    - a. Standard receptacles
    - b. GFCI receptacles
    - c. Weather-resistant GFCI receptacles
  - 2. Wiring device accessories

#### **1.3 DEFINITIONS**

- A. GFCI: Ground-fault circuit interrupter.
- B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

#### **1.4 SUBMITTALS**

- A. Product data: Submit manufacturer's data for each type of product specified.

### **PART 2 - PRODUCTS**

#### **2.1 GENERAL WIRING DEVICE REQUIREMENTS**

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

- B. Comply with the following:
1. NEMA WD 1 and WD 6.
  2. NFPA 70.
  3. RoHS.
  4. UL 498.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
  2. Devices shall comply with requirements in this Section.
- D. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

## **2.2 RECEPTACLES**

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
1. Eaton Wiring Devices/Arrow Hart
  2. Hubbell
  3. Legrand/Pass & Seymour
  4. Leviton
- B. Standard Receptacles:
1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
- C. Ground Fault Current Interrupter (GFCI) Receptacles:
1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
  2. Provide GFCI-type device. Device shall include indicator light that is lighted when device is tripped. Device shall conduct an automatic test every three seconds, ensuring ground fault protection. If protection is lost, power to the unit is disconnected and indicator light flashes indicating that the unit should be replaced. Device shall be designed for installation in a 2-3/4 inch deep outlet box without an adapter.
- D. Weather Resistant GFCI Receptacles:
1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
  2. Listed and labeled as complying with NFPA 70 "Receptacles in Damp or Wet Locations" article.
  3. Provide GFCI-type device. Device shall include indicator light that is lighted when device is tripped. Device shall conduct an automatic test every three seconds, ensuring ground fault protection. If protection is lost, power to the unit is disconnected and indicator light flashes indicating that the unit should be replaced. Device shall be designed for installation in a 2-3/4 inch deep outlet box without an adapter.



4. Receptacle shall have internal locking shutter mechanism that opens when the two receptacle blade slots are penetrated simultaneously or receptacle requires the presence of an object in both right and left contacts to energize the device. Receptacle shall be listed to UL and federal specification WC596-F.

## **2.3 WIRING DEVICE ACCESSORIES**

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
  1. Eaton Wiring Devices/Arrow Hart
  2. Hubbell
  3. Legrand/Pass & Seymour
  4. Leviton
- B. Wall plates for use in interior, dry locations: single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide .04 inch thick, Type 302 brushed stainless steel flush cover plates.
- C. Wall plates for use in interior, dry locations with surface-mounted devices in unfinished areas: Raised galvanized steel with rounded corners.
- D. Wall plates for use in damp or wet locations:
  1. Weatherproof gasketed die-cast aluminum cover.
- E. Blank cover plates shall match adjacent device plates.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades
  1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
  2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors
  1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
  2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Existing Conductors:
  - a. Cut back and pigtail, or replace all damaged conductors.
  - b. Straighten conductors that remain and remove corrosion and foreign matter.
  - c. Pigtail existing conductors is permitted provided the outlet box is large enough.

D. Protection

1. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
2. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
3. Protect installed components from damage.
4. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

E. Device Installation

1. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
2. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
3. 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.
4. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
5. When conductors larger than No. 12 AWG are installed on 20-A circuits, splice No. 12 AWG pigtails for device connections.
6. Tighten unused terminal screws on the device.
7. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
8. Unless otherwise indicated, mount flush, with long dimension vertical.
9. Install receptacles vertically, with ground pin located at the top. Where horizontal mounting is required due to space constraints, install receptacle with neutral blade located at the top.
10. Group adjacent devices under single, multi-gang wall plates.

- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

### 3.2 FIELD QUALITY CONTROL

A. Tests for Convenience Receptacles

1. Diagnostic testing: Use a digital wiring analyzer with digital readout or illuminated LED indicators of measurement complying with UL 1436. Perform the followings diagnostic tests, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems.
  - a. Line Voltage: Acceptable range is 105 to 132 V.
  - b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
  - c. Ground Impedance: Values of up to 2 ohms are acceptable.
  - d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
2. Using the test plug, verify that the device and its outlet box are securely mounted.

- B. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.

**END OF SECTION 26 2726**

## **SECTION 26 2813 - FUSES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and motor control centers; and spare fuse cabinets.
  - 1. Class RK1 Time Delay Fuses
  - 2. Spare Fuse Cabinet.

#### **1.3 SUBMITTALS**

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product Data - include the following for each fuse type indicated:
  - 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
  - 2. Let-through current curves for fuses with current limiting characteristics.
  - 3. Time current curves, coordination charts and tables, and related data.
  - 4. Fuse size for elevator feeders and elevator disconnect switches.
- C. Ambient Temperature Adjustment Information. If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses adjusted.
  - 1. For each adjusted fuse, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
  - 2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
- D. Maintenance Data: For tripping devices to include in maintenance manuals specified in Division 01.
- E. Shop drawing of spare fuse cabinet showing dimensions and features including storage provision for fuse cartons.

#### **1.4 QUALITY ASSURANCE**

- A. Source Limitations: Provide fuses from a single manufacturer.

- B. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- C. ANSI Compliance: Comply with applicable requirements of ANSI C97 "Low Voltage Cartridge Fuses 600 Volts or Less".
- D. UL Listing and Labeling: Items provided under this Section shall be listed and labeled by UL.
- E. Comply with NEMA FU 1.
- F. Nationally Recognized Testing Laboratory Listing and Labeling (NRTL): Items provided under this Section shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

## **1.5 PROJECT CONDITIONS**

- A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

## **1.6 COORDINATION**

- A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver spare fuses stored in locked spare fuse cabinet after cabinet has been installed.

## **1.8 EXTRA MATERIALS**

- A. Maintenance stock - fuses: For types and ratings required, furnish spare fuses, amounting to one unit for every 5 installed units, but not less than one set of 3 of each kind.
- B. Provide three fuse pullers with the spare fuse cabinet.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers - subject to compliance with requirements, provide products by the following:
  - 1. Bussmann Division, Cooper Industries, Inc.
  - 2. Shawmut Division; Gould Inc.
  - 3. Littlefuse, Inc.

### **2.2 FUSES - GENERAL**

- A. General: Provide fuses of types, classes, and current ratings as indicated. Voltage ratings shall be consistent with the circuits on which used.

## **2.3 CARTRIDGE FUSES**

- A. General: Comply with ANSI/IEEE Standard FU1, "Low Voltage Cartridge Fuses." Provide nonrenewable cartridge type fuses.
  - 1. Fuses shall be all of the same manufacturer.
  - 2. Class RK1 Dual Element Time Delay Fuses: Comply with UL 198E, "Class R Fuses."

## **2.4 SPARE FUSE CABINET**

- A. Cabinet: Wall mounted, 18-gauge minimum steel unit with full-length, recessed piano-hinged door with key coded cam lock and pull.
- B. Size: Provide for orderly storage of all spare fuses of this project plus 15 percent spare capacity, minimum.
- C. Finish: Gray baked enamel.
- D. Cabinet Door: Bear the legend in stenciled 1-1/2-inch-high letters, "SPARE FUSES."

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 APPLICATION OF FUSES**

- A. Fusible Switches - apply the following class and types:
  - 1. 30-600 Amperes: Class RK1, time delay.
- B. Combination Starters: Class RK1, time delay.

### **3.3 INSTALLATION**

- A. Provide fuses in all fuse gaps of all equipment provided under this Contract.
- B. Install fuse so that ratings are readable without removing fuse.
- C. Fuses shall not be installed until equipment is ready to be energized.
- D. Install spare fuse cabinet wall mounted where indicated.

### **3.4 FIELD QUALITY CONTROL**

- A. Prior to energization of fusible devices, test devices for continuity of circuitry and for short-circuits. Replace malfunctioning units with new units, and then demonstrate compliance with requirements.

### **3.5 IDENTIFICATION**

- A. Install labels indicating fuse replacement information on inside door of each fusible device.

**END OF SECTION 26 2813**

## **SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

#### **1.2 SUMMARY**

- A. This Section includes circuit and motor disconnects.
- B. Extent of circuit and motor disconnect switch work is indicated by drawings and schedules.
- C. Types of circuit and motor disconnect switches in this section include the following:
  - 1. Equipment disconnects
  - 2. Motor circuit disconnects
- D. Wires/cables, raceways, and electrical boxes and fittings required in connection with circuit and motor disconnect work are specified in other Division 26 sections.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of switch, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Maintenance data for circuit and motor disconnects, for inclusion in Operation and Maintenance Manual specified in Division 01 and Division 26 Section 26 0100 "Basic Electrical Requirements".
- C. Shop Drawings: Submit shop drawings of electrical circuit and motor disconnect switches showing accurately scaled switches, their layouts, and proximity to associated equipment.
- D. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
  - 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.



- E. Maintenance Data: For enclosed switches and components to include in maintenance manuals specified in Division 01. In addition to requirements specified in Division 01 Section "Closeout Procedures," include the following:
  - 1. Routine maintenance requirements for components.
  - 2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
  - 3. Time-current curves, including selectable ranges for each type of circuit breaker.

## **1.4 QUALITY ASSURANCE**

- A. Manufacturers: Firms regularly engaged in manufacture of circuit and motor disconnect switches of types and capacities required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing circuit and motor disconnect work similar to that required for this project.
- C. NEC Compliance: Comply with NEC requirements pertaining to construction and installation of electrical circuit and motor disconnect devices.
- D. UL Compliance: Comply with requirements of UL98, "Enclosed and Dead Front Switches". Provide circuit and motor disconnect switches that have been UL listed and labeled.
- E. UL Compliance: Comply with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use With Copper Conductors" including, but not limited to, tightening of electrical connectors to torque values indicated. Provide electrical connection products and materials that are UL-listed and labeled.
- F. NEMA Compliance: Comply with applicable requirements of NEMA Standards Pub No. KS 1, "Enclosed Switches" and 250, "Enclosures for Electrical Equipment (1000 volts maximum).
- G. Product Selection for Restricted Space: Drawings indicate the location where enclosed switches are to be installed. Verify the suitability for installation in this location, including clearances between enclosures, and adjacent surfaces and other items.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Subject to compliance with requirements, provide circuit and motor disconnects of one of the following:
  - 1. Square D Company
  - 2. Eaton Corporation
  - 3. General Electric Company
  - 4. Siemens

### **2.2 FABRICATED SWITCHES**

- A. Heavy Duty Safety Switches:
  - 1. Provide surface mounted, heavy duty type, sheet steel enclosed safety switches of types, sizes and electrical characteristics indicated on the drawings.

2. Provide switches with quick-make, quick-break type operation, with switchblades that are visible in the 'OFF' position with door open.
  3. Operating handle shall be an integral part of the enclosure base the operating position shall be easily recognizable and pad-lockable in OFF position.
  4. Current carrying parts shall be constructed of 98% conductivity copper, with silver-tungsten type switch contacts and positive pressure type reinforced fuse clips.
  5. Provide disconnect switches having the capability to have auxiliary contacts mounted as required.
- B. Fusible Switches: Heavy duty safety switches as described above, with positive pressure type reinforced fuse clips and fuses of classes and current ratings indicated. See Division 26 Section 26 2813 "Fuses" for specifications. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.
- C. Enclosures shall meet environmental conditions of installed location.
1. Indoor Locations: NEMA 250, Type 1
  2. Outdoor Locations: NEMA 250, Type 3R.
- D. Finish shall be manufacturer's standard gray finish unless otherwise noted on drawings.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECTS**

- A. Examine elements and surfaces to receive enclosed switches for compliance with installation tolerances and other conditions affecting performance.
1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Install circuit and motor disconnect switches as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA and NECA's "Standard of Installation" and in accordance with recognized industry practices.
- C. Coordinate circuit and motor disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.
- D. Install disconnect switches for use with motor driven appliances, and motors and controllers within sight of the controller position unless otherwise indicated.
- E. Coordinate layout and installation of switches 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.
- F. Install power wiring. Install wiring between switches and control, and indication devices.
- G. 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.
- H. Where the motor is located out of sight or more than 50 feet from its circuit breaker (or combination starter) this Contractor shall provide a properly rated motor circuit switch at the motor location in accordance with the CIRCUIT AND MOTOR DISCONNECT section of this Specification.

### **3.2 NEUTRAL BAR**

- A. When a neutral conductor is required for the load connected to a safety switch, the Contractor shall provide a copper neutral bar in the safety switch. This copper neutral bar shall be furnished by the manufacturer of the disconnect switch and shall be designed to be installed within the particular disconnect switch installed.

### **3.3 GROUNDING**

- A. Install equipment grounding connections for switches with ground continuity to main electrical ground bus.
- B. Provide an equipment grounding kit with all disconnect switches.
- C. Connections shall be tightened in accordance with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors".

### **3.4 FIELD QUALITY CONTROL**

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each enclosed switch, component, and control circuit.
  - 2. Test continuity of each line- and load-side circuit.
- B. Testing Agency: The Contractor shall perform the following testing or engage a qualified independent testing agency to perform testing.
- C. Testing: After installing enclosed switches and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
  - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches 200 amps and larger. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

### **3.5 CLEANING**

- A. Upon completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

**END OF SECTION 26 2816**